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When the American Orthopedic Association elects a man to be its President, it confers much honor upon that man. Permit me to extend to you my most sincere thanks for your unwarranted generosity in making me your President, and also permit me to assure you that I am not unmindful of the responsibilities that go hand in hand with the honor which you have bestowed upon me.

The President is required to prepare an address to be delivered before the Association. The term "address" brings to us all memories of many lengthy dissertations which have been delivered by masterful orators who have held us spellbound by their powers. I must content myself by presenting to you two thoughts which have been much in my mind—thoughts which I shall attempt to convey to you in a very few words. The brevity of my remarks will conserve the time of the Association and will, I trust, prevent befogging by needless words the points which I wish to make.

During the childhood years of the Association, the membership was small—every member knew every other member intimately and the annual meetings simulated, to a large degree, family gatherings. The President, with the able assistance of the Secretary, conducted most of

the affairs of the Association. What the President thought and said, or rather, what he was told by the Secretary to say, usually was accepted as law. To be sure, there was an Executive Committee, but even the duties of this honorable body were largely carried on the broad shoulders, and by the infinite zeal, of the Secretary.

As time has gone on, great changes have occurred in the make up of the Association and in the manner of conducting its affairs—changes that have been brought about by the expanding scope of Orthopædic Surgery, by the expanding geographical area whence come our members, and by the ever and rapidly increasing number of physicians who are interested in our special work.

Early in the history of the Association, it was deemed wise to have an Editorial Committee and a Membership Committee. At first the duties of these committees were not difficult. Those of the former were completed with the publication of the Transactions of the Association; those of the latter required but little time or thought, as the number of applications for membership was small and the qualifications of each applicant were well known through personal observation.

After the virgin growth of timber had been exhausted in the presidential chair factory, a Nominating Committee was authorized by the Association and thus ended the good old days. No more shall presidential plums be promised two and three years in advance!

With the expanding boundaries of Orthopædic Surgery came new problems in the preparation of the programme for the annual meeting. Formerly, practically all of the subjects pertaining to Orthopædic Surgery could be found on the programme of a single meeting; this is now impossible owing to the manifold ramifications of the specialty. We now have a Programme Committee whose duty it is to prepare a well balanced programme for each meeting and to see that every subject germane to Orthopædic Surgery is allotted an appropriate amount of attention over a period of years.

An increased number of applications for membership coming from all parts of this country and Canada added greatly to the responsibilities of the Membership Committee. It became more and more difficult to do justice to the Association and to applicants. The obtaining of credentials and the presentation of a thesis by applicants proved to be an inadequate method of judging the desirability of admitting applicants to membership. The present system of having each applicant pass a probationary period of three years safeguards, to a greater extent, the interests of the Association.

In spite of all precautions that can be taken an undesirable applicant

will, from time to time, be admitted to membership in the Association. We have been working for years to build up an Association for the advancement of Orthopædic Surgery. We have largely perfected its organization and have safeguarded the portal of entry to membership. What I wish to propose is some method of cleaning house from within, whenever a house-cleaning is desirable. A single blot on a sheet of writing paper brings up visions of the scrap basket. An irresponsible member in an association is the keynote of discord. Why should the American Orthopedic Association permit its membership roll to be blurred by the name of any man who is unworthy of its best traditions? It is time that the American Orthopedic Association issued a proclamation of independence to the effect that, when a member becomes persona non grata to the majority of other members, he shall forfeit his membership in the Association. The safeguarding of the membership of the Association is a subject that is very dear to my heart. I beg of you to cherish the goal of an ideal membership.

The second thought that I wish to present to you pertains to medical literature.

At a meeting of the Association of American Medical Editors which was held in New Orleans in 1920, a number of papers were presented on the subject of the debt of the medical profession to current medical literature. In this series of papers, the great value to the profession of good medical publications was clearly demonstrated and the obligation of the profcssion to medical writers and editors was pointed out. The scope and methods of presentation of American medical literature were compared to those of other countries and suggestions were made as to the possible need of other types of medical publications in America.

I venture to add a suggestion which, if carried out, would, I think, help to make current medical literature of still greater value. Medical articles are written presumably for the purpose of permitting the profession to profit by the observations of the writers. It not uncommonly happens that writers change their opinions and modify or entirely discard the procedures which they have perhaps but recently set forth in print. How seldom are these changed opinions published! Would it not be a good plan for medical writers to consider it a moral obligation to keep the readers of their articles posted as to their changing or changed opinions? Would it not be wise for medical editors to inquire from contributors to their publications whether or not, after the lapse of a certain time, they still maintain the opinions which they have expressed in their published articles? By so doing, information which is the basis of knowledge could be obtained.

LOOSE BODIES IN JOINTS AND BURSAE DUE TO SYNOVIAL OSTEOCHONDROMATOSIS.*

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Loose bodies of intrinsic origin found in joints may be classified in two groups, those composed of unorganized tissue, the outstanding example being the rice bodies or corpora oryzoidea, not infrequently seen in cases of tuberculosis, and those composed of organized tissue, cartilage, fibrocartilage, or bone, seen in cases of osteo-arthritis, osteochondritis dissecans, and osteochondromatosis.

Osteochondromatosis is a rare condition found in various joints and sometimes in the bursae near the joints. The synovial membrane becomes the site for the formation of osteocartilaginous bodies, often great in number, consisting of cartilage, or bone, or both. The condition is a benign neoplasm. No record can be found in the literature or in our own cases of metastasis in any true case of osteochondromatosis, although a local recurrence is not uncommon following removal of the bodies. The condition is distinct from osteochondritis dissecans and osteo-arthritis, in which loose bodies are formed. In osteochondritis dissecans, which rarely occurs in any joint except the knee, the bodies arise from the articular cartilage, usually the internal condyle, and in osteo-arthritis they originate in the marginal osteophytic growths.

REVIEW OF LITERATURE.

In a careful review of the literature we have found reports of twenty-five cases which seem to be osteochondromatosis. This condition has not been well catalogued, and it has been necessary to cull many of the cases from those indexed merely as loose bodies. Besides the twenty-five cases, numerous references have been made by various authors to cases which they have observed, but of which complete reports are lacking. Various terms have been used to describe the condition, such as diffuse

*Read before the New York Academy of Medicine, New York City, February 16, 1923.

enchondroma of the cavity of the joint, chondromatosis and chondroma of the capsule of the joint, chondromas of the synovia, and osteochondromatosis. Three of the twenty-five cases were reported by one of us [16, 17, 18, 19] in 1916, 1917, and 1918, respectively. Since then we have observed twelve cases, making a total of fifteen observed in the Clinic. We are also reporting three cases which we believe to be osteochondromatosis, but in which definite proof is lacking.

Since 1558, when Ambrose Paré incised a knee-joint and released a loose cartilage, various observers have manifested an exceptional interest in these bodies in the joints. Credit has been given to Laennec, who, in 1813, gave the first description of the formation of bodies in the joints by the process under discussion. Laennec believed that the bodies originated in the subsynovial tissues. Rokitansky held the opinion that the "fibrocartilaginous concretions" developed in the subserous cellular tissue, or in the serous tissue itself. Sir B. Brodie asserted that the bodies usually had their origin in the synovial membrane, but he described certain specimens of which the site of origin seemed to be outside this membrane. Both Rainey and Kölliker gave descriptions of the gross and microscopic appearance that are hard to improve on, even at the present time. Virchow described a case which was probably a manifestation of what we now call osteochondromatosis. Since then various writers have described the condition. [1, 6, 10, 14, 20, 23, 35].

A review of the subject was published in 1902 by Joseph Bryant. Marsh, Bland-Sutton, Berry and Fisher have reported the removal of 1047 bodies from a knee-joint, and all apparently refer to the same case. There was, according to the reports, nothing abnormal in the synovial membrane, so whether or not this case is true osteochondromatosis can only be surmised. The large number of bodies certainly suggests osteochondromatosis. Carothers, in 1914, reported a case which was exceptional in that both knee-joints were involved. One of us [16, 17, 18, 19] in 1916, recorded the condition in a knee-joint, in 1917 in a knee-joint, and in 1918 in an elbow. Fisher has reported three cases, one of the three being Marsh's, and in discussing the etiology said that it was closely related to the etiology of tumors. Lamson's discussion of the subject included a report of a case in which six bodies were removed from the knee-joint. Strange to say, the bodies apparently originated in the tibia.

In the early part of this century, renewed interest in the subject was shown by German writers. Reichel, in 1900, gave an excellent report of a case of multiple loose bodies in a knee-joint. He was at a loss to

account for their presence and suggested an agent of contagion, although he was unable to find an inflammatory process. Whether he meant that he believed the cause to be infection, as we ordinarily understand the term, is open to doubt. Contemporary authors on the subject have, however, credited him with the theory of infection. Reichel attributed to Müller a report at a surgical meeting of a case of loose bodies in a metacarpophalangeal joint, but Müller did not give a complete report in the literature until 1902. Riedel, in 1903, reported finding the bodies in a wrist-joint. Certain of the carpal joints were affected on the ulnar side. Simple arthrotomy had been performed, and Riedel extirpated the capsule; there was a recurrence within one year. Langemak, in 1904, recorded the involvement of the astragaloscaphoid joint. Hagemann later questioned Langemak's statement that the anterior epiphysis of the astragalus is the site of origin, arguing that the tarsal bones do not have epiphyses. Hagemann believed that the bodies originated in the joint. He accepted Langemak's case, however, as one of osteochondromatosis. Lexer, in 1907, mentioned finding the bodies in a knee-joint; the suprapatellar pouch had broken and the bodies were in the muscle. He must have feared recurrence, for he removed 11 cm. of the lower end of the femur and 5 cm. of the upper end of the tibia, and inserted a piece of ulna removed from a cadaver. The wound suppurated for five months, but, on removal of the graft, ankylosis soon occurred. Lexer suggested the hypothesis that since the component parts of the joint are all developed from the same layer of the axial blastema, the condition is due to a faulty mesenchymal differentiation in the formative process of the joint. Lichtenberg, in 1907, recorded the case of a knee-joint in which he had performed a synovectomy with good results. Kobylinski, in 1909, resected a knee-joint for osteochondromatosis. Rehn, in 1911, reported a case of bodies in the left elbow. Bibergeil, in 1913, reported the condition in the carpal joints. Hagemann, in 1913, reported that he had resected a shoulder, removing the head of the humerus, the capsule, and the rim and surface of the glenoid fossa. He believed that the bodies originated from the synovial membrane; they were most numerous in the folds and pockets where the membrane was reflected from the bone. This case he considered unusual in that the formations encroached on the cartilage of the head of the humerus. He explained this by calling attention to the fact that at the fourth month in fetal life the margin of the articular surface of the bone is covered by a cellular and vascular tissue which is a prolongation of synovial membrane. Hence he considered that the changes on the articular surface really came from synovia and not from cartilage.

In his case the two bursae close to the shoulder each contained a loose osteocartilaginous mass, and the lining was clearly the site of its formation. In the only shoulder from which we removed multiple loose bodies we could not definitely prove that the condition was, or was not, due to osteochondromatosis (Case 9). In the roentgenogram, evidence of osteo-arthritis was seen at the margins of the joint. We removed the bodies through such a small incision that no inspection of the synovial membrane was possible, but from the roentgenogram and from the gross and microscopic appearance of the bodies we are convinced that it is a case of osteochondromatosis and have so classified it. Eden, in 1914, resected the head of the left femur, removing many loose bodies and, after moving the trochanter down lower on the shaft of the femur, implanted the upper end of the femur into the acetabulum. Kobylinski's report of a case of the condition in an elbow-joint appeared in the German literature in 1914. In the same year, Troell, of Stockholm, described a case in which the knee-joint was affected. Kopp, in 1916, placed on record three cases, two of which appear definitely to be osteochondromatosis. His examination in one case convinced him that the bodies start as osteomas, because he did not find cartilage around the smaller bodies. Kienbock, in 1917, reported formations in two knees, one elbow, and one ankle, calling them chondromas of the capsule of the joint. The conditions which he described do not correspond with our understanding of osteochondromatosis, but they may represent, as he claimed, a more advanced development of the same process, and undoubtedly are closely related to it. In 1920, Lotsch reported two cases involving the knee-joint, and in 1921, Ziegner presented a case in which the elbow-joint was involved.

ETIOLOGY AND PATHOLOGY.

There seems to be no direct evidence that infection plays a part in the development of this interesting condition. Heredity, so far as the literature or our own experience proves, is a negligible factor. Certain authors have suggested that osteo-arthritis is related, in some manner, with osteochondromatosis. It is true that there is occasionally a marginal lipping, but this probably is a secondary finding. Trauma, recent and old, deserves consideration; in exactly one-half of our cases there were histories of severe trauma sustained years before. The condition in the knee reported by one of us ([17]) in 1917 seemed to have a definite relation

to severe trauma, as the symptoms of locking followed soon after the subsidence of the effusion which persisted for six months. Many who have written on the subject mention trauma as a factor. In further support of this theory it may be said that fifteen of our eighteen patients were men. The fact that the majority were between twenty and forty years of age, in the active period of life, is also significant. In the cases collected from literature the sex was more evenly divided. While we may acknowledge that trauma is a factor, it cannot be more than contributory.

When we consider this unusual condition from the viewpoint of etiology we find ourselves in the same maze that is encountered in studying the etiology of tumors. We believe, however, that we are dealing with a benign neoplasm. Our one case in which osteochondromatosis was definitely present in the knee-joint and a chondroma invaded the lower epiphysis of the femur is very suggestive. Although malignancy could not be determined by exploratory operation, the tumor in the femur soon revealed signs of greater activity, and amputation was performed. A rapidly growing chondrosarcoma was found in the lower end of the femur, but malignancy was not found in the joint itself. The patient died in cachexia with multiple metastatic growths in the lungs. Possibly if the trauma is very severe, cells are squeezed into the synovial fluid of the joint and, being nourished by it, multiply sufficiently to form bodies. This hypothesis might account for those cases in which the synovial membrane is found to be normal. From the descriptions in the literature and from observation of our own cases it appears that the synovial membrane undoubtedly forms bodies composed of cartilage, bone, or both. In the embryo, the proton of the limb is filled with mesenchymal tissue which later forms bone, cartilage, and synovial membrane. Lexer, building a theory on the teaching of Virchow and Ribbert, concludes that these chondromatous bodies develop from scattered embryologic cartilaginous rests which have resulted from a faulty mesenchymal differentiation during the formation of the joint. Before a joint is formed the cartilages which represent the future bones are separated by undifferentiated mesothelium. Certain of these cells undergo mucoid degeneration and form the cavity of the joint; other cells become spindle-shaped and form articular cartilage, and the cells at the side of the cavity form the synovial membrane ([37]). The bursal cavities, which are often connected with the joints, undoubtedly are closely related embryologically. Until we know why one group of mesenchymal

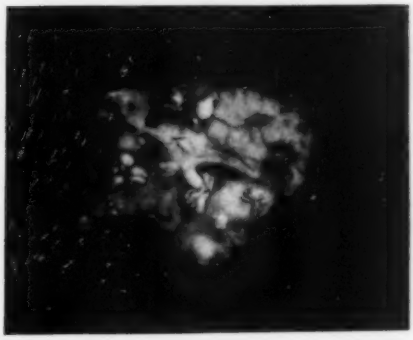
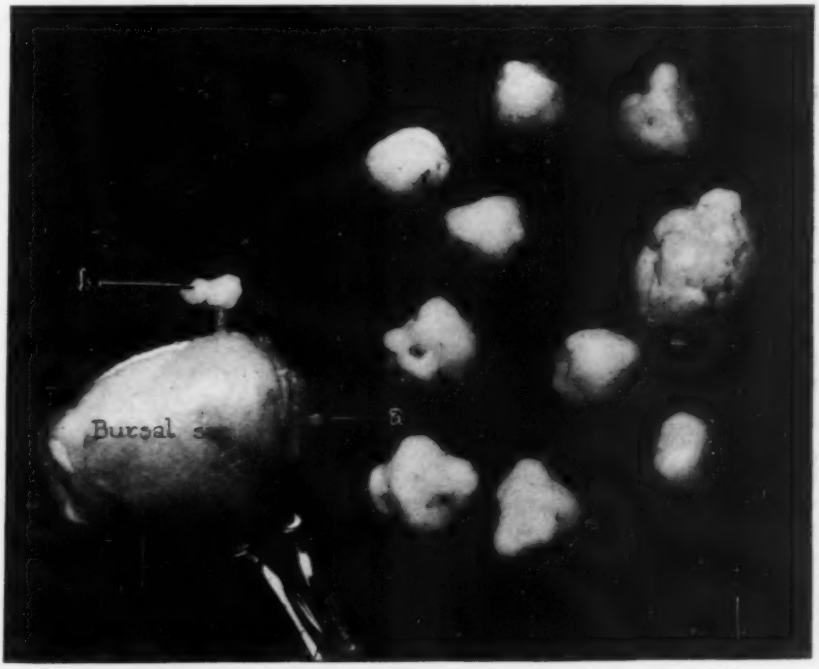


Fig. 1 (A414987). Synovial membrane with attached hypertrophic villi and pedunculated bodies.



Fib. 2 (A346313). Bursal sac, from which ten bodies were removed, has been inverted and stuffed with cotton to show the vascular hypertrophic villus (a) and the pedunculated osteocartilaginous body (b).

cells forms a mucoid fluid, whereas another group develops into cartilage, and another into synovial membrane, it will be difficult to determine what causes cartilage and bone to form in synovial membrane.

The appearance of the synovial membrane in osteochondromatosis is characteristic. It is usually loose, wrinkled, pouched, and somewhat congested. Multiple fibrous tags hang from the membrane, but the articular surfaces and the fibrocartilages and intrinsic ligaments in the knee appear to be normal. There is often a little hypertrophic arthritis manifested by osteophytic hypertrophy at the margins of the joints. The fibrous tags vary in size, both in diameter and length. Some are pedunculated, and the tips of the bulbous ends are covered with cartilage (Fig. 1). As these cartilaginous-tipped bulbs increase in size and weight, their pedicles break and they are cast free in the cavity of the joint to wander around and increase in size. On gross section, the bodies are seen to be made up mostly of cartilage. Various degrees of calcification and ossification are seen. Often bone in the interior is distributed at random in small flakes and surrounded on all sides by cartilage.

Microscopic examination in our cases revealed a series of interesting processes. The specimens chosen for study were taken from a bursa (Case 7) removed from beneath the medial head of the gastrocnemius muscle. Since the entire bursa was removed, the lining could be readily inspected and areas chosen for study, an opportunity not present in cases in which a joint is involved (Fig. 2). The vascular hypertrophic villus (Fig. 3) which was one of a great number on the wall of the bursa, illustrates an early stage in the formation of the bodies. Microscopically, it was found to consist principally of connective tissue supporting a great number of capillaries which were especially numerous just beneath the synovial membrane. In one area there were a number of fat cells, but no cartilage or bone was seen. In a few regions, there was definite lymphocytic infiltration.

A pedunculated, bulbous, osteocartilaginous body which was found attached to the wall of the same bursa illustrated a later stage in the process of the formation of loose bodies. This body was found to be a spherical fibro-osteo-cartilaginous shell filled with fatty tissue and spurs of bone. The pedicle, which connected the body to the synovial membrane, was fibrous and avascular; this accounted for the fact that blood-vessels within the attached body were thrombosed and necrotic. The fibrous tissue surrounding the body gradually merged into fibrocartilage (Fig. 4). Deeper than this was a zone of calcified cartilage, and then came a sharp transition to true bone. It was profitable to study the

Fig. 3 (A346313). Vascular hypertrophic villus. (X8). a, Villus; b, pedicle; c, wall of bursa.

Fig. 4 (A346313). Pedunculated, bulbous, osteocartilaginous body. (X50) (See Figure 2 b). a, Fibrous tissue surrounding body; b, zone of fibro-cartilage; c, line of calcified cartilage; d, bone; e, thrombosed necrotic blood vessels; f fatty center of body; g, portion of fibrous avascular pedicle.

state of preservation of the various tissues in the body whose blood supply had been cut off. The cells of the cartilage appeared to have been well nourished, for the nuclei were large and the cells filled the spaces in the matrix. The bone was not so well preserved as the cartilage, for the bone cells showed certain evidences of necrosis; they did not completely fill the lacunae, and many of the nuclei were pyknotic. The absence of osteoblasts also indicated that active bone formation had ceased. The fatty tissue was still fairly well preserved. Well preserved cartilage was found near the surface of the large free bodies; indeed, in certain areas it resembled closely the normal hyalin articular cartilage (Fig. 5). Bone was found only deep within these free avascular bodies (Fig. 6). The tissue was definitely necrotic, for the nuclei were either very pyknotic or not visible, and osteoblasts could not be found. The fatty tissue was almost completely disintegrated.

One of the bodies which was torn from the synovial membrane at the time of operation was examined, and here the condition was quite different from that found in the avascular bodies (Fig 7). In the vicinity of blood-vessels, bone was in excellent state of preservation, as evidenced by the cells of the bone which filled the lacunae and by the presence of osteoblasts. The fat was also well nourished. This body consisted chiefly of thin flakes of bone, a large quantity of fatty tissue, and a small portion of cartilage.

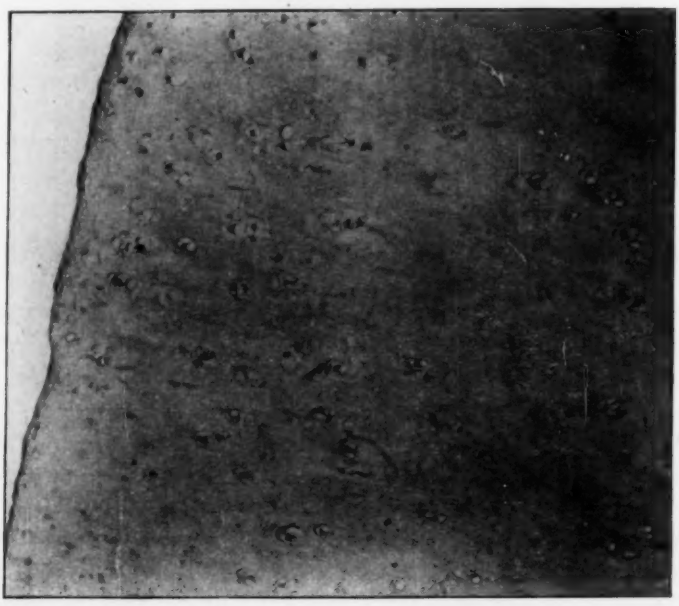


Fig. 5 (A346313). Section of cartilage near surface of large free body. (X100).

Fig. 6 (A346313). Necrotic center of a large free body. (X100). a, Laminated bone; b, necrotic bone cell with pyknotic nucleus; c, disintegrated fat.

Judging from the condition shown microscopically it is safe to conclude that cartilage may be nourished by the synovial fluid. This bears definitely on the question of the nutrition of articular cartilage. Also, it would seem that active living bone demands a blood supply, a point which has a bearing on the fate of osseous transplants; this, however, is not discussed here.

SYMPTOMS AND DIAGNOSIS.

The symptoms at the onset may be vague, the patient complaining that "things do not feel right in the joint". Then comes definite catching and possibly locking, the anatomic structure of the joint having much to do with the character of the symptoms. A history of trauma, recent or remote, is often elicited. The disability is greater in the knee than in other joints. The knee joint being comparatively super-

Fig. 7 (A346313). Section of large body with a blood supply. (X100). a, Vessels containing blood; b, osteoblasts; c, well preserved bone; d, well preserved fat; e, membrane covering the body.

ficial, the patient often volunteers the information that he has felt the loose bodies, and on palpation the knee may feel like a sac of marbles. The locking or catching is not so severe as in cases in which one of the semilunar cartilages is at fault, and effusion following an attack is not as marked. The bodies may be carried for years in the suprapatellar pouch, or in the posterior compartment, with only occasional locking. In the elbow joint often the first symptom is inability fully to extend the forearm, and usually this is sooner or later followed by catching or locking. We have observed but one case in the shoulder joint. The symptoms were severe; the catching occurred frequently, and was accompanied by acute pain. Symptoms in the other joints vary according to the anatomic structure of the joint.

Osteochondromatosis in the knee joint may be confused with derangements due to fractured or torn semilunar cartilages, but the presence or absence of loose bodies can be definitely determined by the roentgenogram (Fig. 8). If bodies are present they may be due to

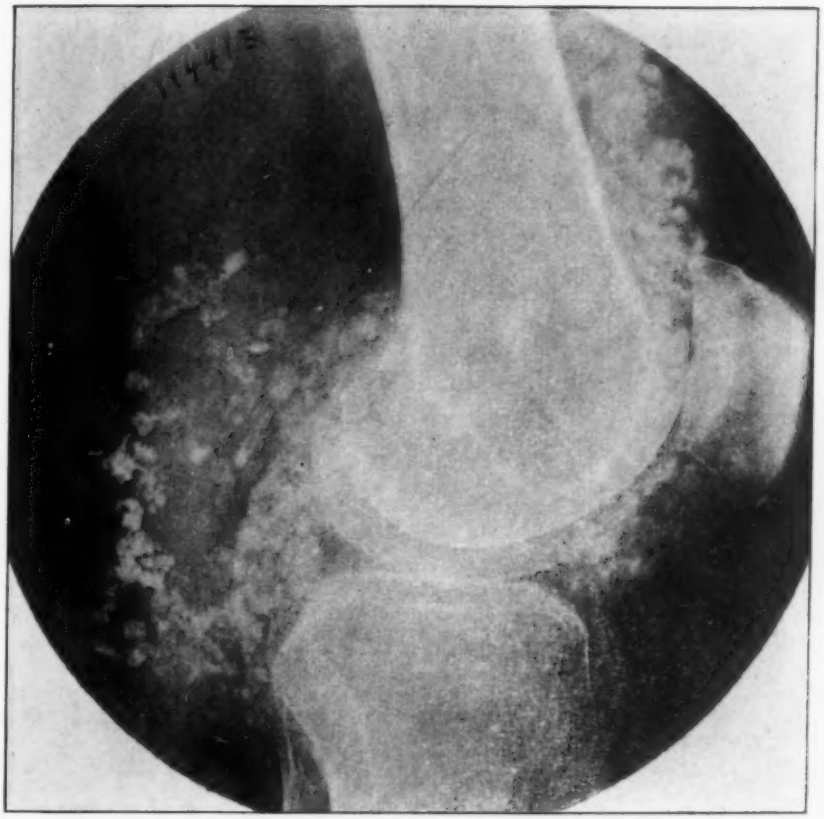


Fig. 8 (A114418). Osteochondromatosis of the knee.

osteochondritis dissecans or osteo-arthritis. In the former, the depression on the internal condyle where the body or bodies originate will be shown in the roentgenogram. In the latter, the marginal lipping is evident and the larger bodies may have a core that casts a denser shadow, and as a rule the patient is older. In osteochondromatosis of any joint, the number of the bodies (twenty-five or thirty are not at all unusual) is the outstanding feature (Fig. 9); the joint is often filled with them (Fig. 10). Beyond this, the roentgenogram does not aid in the differential diagnosis, and only when the capsule is opened for inspection and the typical conditions demonstrated is the diagnosis certain. The bodies are variable in shape and hence the shadows vary. Rounded, smooth, and often slightly oblong forms are attained, particularly in those joints in which the bodies wander freely. In the bursae

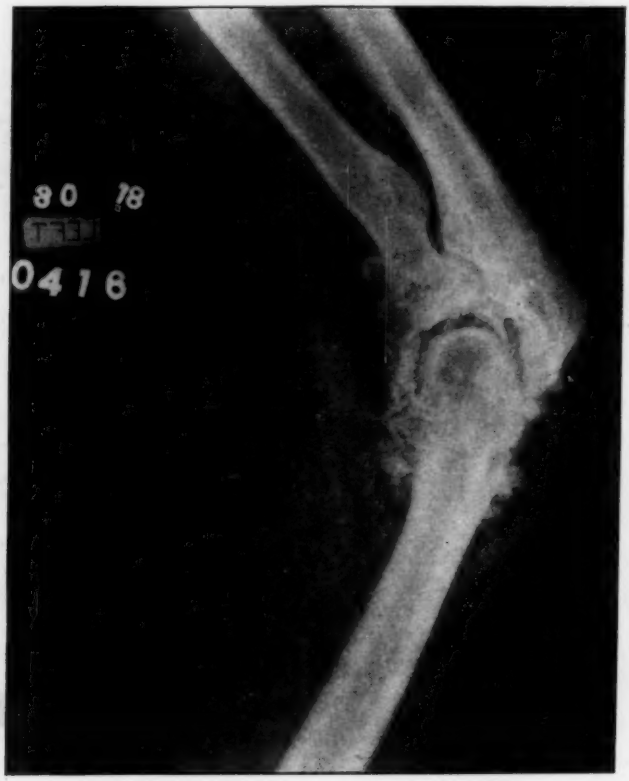


Fig. 9 (A240416). Osteochondromatosis of elbow joint.

or tendon sheaths, where less freedom is possible, the bodies are usually more irregular and are of a cauliflower or mulberry type (Fig. 11).

TREATMENT AND PROGNOSIS.

The treatment is essentially surgical. In the literature we have noted such radical procedures as amputation, resection, and synovectomy. We have removed the bodies by the simplest possible route, and as recurrences have been rare, we see no need to change our procedure. Therefore, the operation practically consists of an arthrotomy, the approach to the capsule being the chief concern. In the knee joint the splitting of the patella longitudinally gives the best exposure for a satisfactory exploration of the anterior compartment and the suprapatellar pouch. The ordinary gallstone scoop is convenient in exploring for these

Fig. 10 ((A240416). One hundred and seven bodies from the elbow joint.

bodies. If the bodies are in the posterior compartment, the postero-lateral incisions described by one of us ([17]) are convenient. In the shoulder joint the capsule is readily accessible posteriorly, and the bodies may be worked around to the incision. The capsule may be entered anteriorly through the pectoral muscles. In the elbow, the posterior capsule may be opened by a straight incision and the olecranon fossa explored. The anterior portion of the elbow joint may be explored by raising the aponeurotic origin of the flexor muscles from the internal condyle and entering the capsule from that point. By flexing the elbow the scoop may be pushed across the joint to the outer side and even the finger introduced. We have had no occasion to explore the hip joint, but the anterior incision or the posterior Kocher incision should be sufficient for a simple arthrotomy. (Table 1).

Fig. 11 (A393209). Bodies from the flexor tendon sheath of finger.

REPORTS OF CASES.

Case 1 (A131188).—T. K., a farmer, aged forty years, with osteochondromatosis of the right knee joint and chondrosarcoma of the lower right femur, was examined May 19, 1915. Twenty-two years before, he had fallen and broken a bone near the right knee, but had recovered in about one month and had had no further trouble until five years before his registration at the Clinic. He noticed a swelling just above the knee. This had steadily increased, the increase becoming more rapid within the last three to six months. He had limitation of motion and walked with a limp.

On May 27, the knee was explored through a median incision through the patella, and multiple loose bodies, which had clearly originated in the synovial membrane, were removed. A tumor in the lower end of the femur was explored through a separate incision and was reported by the pathologist to be a chondroma. On September 23, on account of a marked increase in the size of this tumor, an amputation was performed in the middle third of the thigh. The pathologist reported chondrosarcoma of the lower end of the femur. Osteochondromatosis did not recur in the knee. On December 13, a roentgenogram of the chest revealed multiple metastatic growths. The patient died March 5, 1916.

TABLE 1. SUMMARY OF CASES.

Case	Sex Age	Part involved	Trauma	Bodies	Remarks
A131188	40 M	Knee	Yes	Multiple	Associated with chondrosarcoma of lower end of femur
A157963	26 M	Knee	Yes	25	
A201151	50 M	Knee and nearby bursae	No	104	
A239850	62 M	Bursa beneath gastrocnemius	No	4	
A243018	29 M	Knee	Yes	1	
A41317	60 F	Knees	No	8	Bodies not removed from one knee
A346313	50 M	Both knee joints and bursae	No	14	
A114418	49 M	Knee	Yes	A great many	No operation
A238014	20 F	Shoulder	No	10	
A126099	37 M	Elbow	No	31	
A196125	26 M	Elbow	Yes	65	
A240416	24 M	Elbow	No	107	
A86594	23 M	Elbow	No	21	
A414987	66 F	Elbow	Yes	3	
A393209	33 M	Flexor tendon sheath of finger	Yes	5	
A38869	28 M	Knee	No	200	
A123360	28 M	Knee	Yes	16	
A272634	26 M	Elbow	Yes	12	

This is the only case in our series in which malignancy was associated. We believe that the tumor in the knee was benign, whereas that in the bone became malignant.

Case 2 (A157963).—J. B. E., an oil driller, aged twenty-six years, with osteochondromatosis of the left knee, was examined April 21, 1916. Ten years before, he had sustained a severe trauma which "dislocated" the knee. Effusion followed for six months and, later, locking.

On April 27, nineteen loose osteocartilaginous bodies were removed from the anterior compartment of the knee joint. The bodies clearly arose from the synovial membrane. On June 23, six loose bodies were removed from the posterior compartment of the joint ([16]).

Case 3 (A201151).—J. Z., a farmer, aged fifty years, with osteochondromatosis of the left knee and bursae about the knee, was examined September 18, 1917. The patient had had a "bunch" on the left knee for two years, which gradually increased in size and caused pain and limitation of motion. There was no history of trauma.

Examination revealed a prominence on the anteromedial aspect of the left knee and a hard mass in the left popliteal space. The roentgenogram revealed multiple mulberry-like shadows; the same condition was shown in the right knee.

On September 15, 1917, and March 11, 1920, multiple loose bodies were removed from the bursae and the capsule of the joint. Also, a chondroma was removed from the upper third of the tibia beneath the popliteus muscle. The patient was only partially relieved of his symptoms. The extra-articular loose bodies were in definite sacs, probably abnormally placed bursae lined with synovia. The synovial membrane of the joint showed many small, pedunculated, cartilaginous bodies.

Case 4 (A239850).—R. P. McT., a retired farmer, aged sixty-two years, with osteochondromatosis of the bursa beneath the right gastrocnemius muscle, came to the Clinic on July 26, 1918, complaining of a growth in the right popliteal space which he had noticed for ten years. For twenty-five years he had had slight attacks of "rheumatism" in the knees. A slightly nodular tumor, which seemed to be outside the joint, could be felt in the right popliteal space. A roentgenogram of the right knee revealed multiple calcified bodies posterior to the condyles.

On August 1, the patient was placed under ether anesthesia and four loose bodies were removed from the bursa under the right gastrocnemius muscle. The bodies measured 2.2 cm., 0.6 cm., 1.9 cm., and 1 cm. in diameter, and we concluded that they originated in the lining of the bursa, because in other areas of the bursal wall were a few attached bodies about 0.15 cm. in diameter.

Case 5 (A243018).—G. J. M., a lumber retailer, aged twenty-nine years, with osteochondromatosis of the right knee, was examined August 21, 1918. He complained of soreness in the right knee and the sensation of something slipping loose in the joint. In 1914, while scuffling, he had twisted the right knee. It "burned" somewhat at the time. One month later he noticed a swelling "the size of a hickory nut" on the outer side of the knee-cap. The body had been felt, but could not be located at the time of examination.

Exploration was advised. On August 29, through an internal hockey-stick incision, a body 2 by 1.05 by 0.05 cm., which the pathologist reported to be composed of cartilage, was removed from the intercondylar notch. Lying around on the synovial membrane and attached to it in most instances, were small flakes of cartilage about 2 mm. in size. Several of the large flakes and a few of the small were removed, and an area of the synovial membrane which contained six or eight.

Case 6 (A41317).—J. L., a woman, aged sixty years, with osteochondromatosis of the right knee-joint, was examined June 26, 1920. The patient complained that since 1908 her knees had ached, the right knee being worse. At times she had pain accompanied by a feeling that something had slipped in the joint.

Roentgenograms revealed arthritis of the right knee-joint, with multiple loose bodies. On July 10, four large and four small loose bodies were removed from the suprapatellar pouch of the right knee-joint. Some of the bodies were still attached to the synovial membrane by fibrous pedicles. Marked hypertrophic arthritis was present. Since the bodies in the left knee were not causing symptoms they were not removed.

Case 7 (A346313).—P. M., a cabinet-maker, aged fifty years, with osteochondromatosis of both knees, was examined January 14, 1921. The patient complained of a smarting pain in both knees on standing, and with motion, of six years' duration. Four years before, loose bodies had been removed elsewhere from both knee-joints.

The roentgenogram revealed multiple loose bodies within the left knee-joint and posterior to each knee. On January 20, the bursa beneath the inner head of the right gastrocnemius muscle was excised, with ten rough, irregular, loose bodies which it contained (Fig. 2). Several small bodies and countless hypertrophic villi were attached by pedicles to the synovial membrane. Two coral-like bodies were removed from the bursa beneath the inner head of the left gastrocnemius muscle, and two more smooth bodies were taken from the joint proper of the left knee.

The incisions were closed without drainage. Microscopic examination revealed the conditions shown in Figures 3, 4, 5, 6, and 7. On January 14, 1921, the patient wrote that he was greatly improved, but not completely relieved by the operation.

Case 8 (A114418).—G. G. H., a farmer, aged forty-nine years, with osteochondromatosis of the left knee, was examined September 3, 1914. The patient complained of limitation of motion and swelling of the left knee. Twenty-nine years before, he had been incapacitated for three weeks because of trauma to the left knee. For twenty-four years he had had no further trouble. Four years before, a swelling developed after hard work. Since then there had been gradual stiffening, and a hard tumor had formed in the popliteal space. There was no pain and the patient was not incapacitated.

The roentgenogram (Fig. 8) revealed dense calcium deposits around the left knee, with normal articular surfaces. The large number of mulberry and shot-like shadows was typical of osteochandromatosis. On examination it was found that the left knee was filled with small, hard bodies which gave the sensation of crepitus when squeezed. One mass seemed to be fixed to the tibia. Motion was somewhat limited. The patient deferred operation.

Case 9 (A238014).—A. H., a young woman, aged twenty years, with osteochondromatosis of the right shoulder, was examined July 9, 1918. The patient complained of pain and aching of the right arm and shoulder, persisting for twelve years. She complained chiefly of sudden attacks of severe pain, lasting about five minutes and followed by residual soreness. These attacks sometimes followed reaching with the arm, which could not be lifted above the head.

The roentgenogram revealed multiple calcified deposits in the right shoulder joint. On July 18, ten loose bodies were removed from the right shoulder through a posterior incision. The site of origin was not determined at the time of operation because the incision was small, and the bodies were worked around until they could be removed with a gallbladder scoop. The large number, the size and consistency of the bodies, and the age of the patient, however, led us to make a diagnosis of osteochondromatosis.

On December 5, 1919, a roentgenogram revealed the recurrence of small loose bodies in the shoulder joint. It was thought best to delay operation. The patient's disability was much less, but she had had occasional attacks of pain.

Case 10 (A126099).—I. O., a farm laborer, aged thirty-seven years,

with osteochondromatosis of the left elbow, was examined March 9, 1915. He complained of stiffness in the elbow, which had been gradually increasing for five years.

The roentgenogram revealed a number of bodies in the region of the left elbow-joint. On March 18, thirty-one intracapsular bodies were removed from the left elbow. The pathologist reported that the bodies were composed of cartilage. Although it was not possible to inspect the synovial membrane, the diagnosis of osteochondromatosis was made because of the large number of bodies, their shape and consistency, and the age of the patient. There was no evidence of hypertrophic arthritis.

On January 2, 1919, the patient returned to the clinic because symptoms had developed in the right elbow similar to those for which the left elbow had been treated. The left elbow had not given trouble since operation, and the range of motion was improved. On January 7, an intra-articular exostosis was removed from the posterior surface of the medial condyle of the right humerus. No loose bodies were encountered in this joint.

Case 11 (A196125).—A. W. H., a locomotive engineer, aged twenty-six years, with osteochondromatosis of the right elbow, was examined June 1, 1917. The patient complained of swelling and stiffening of the right elbow. Thirteen years before, he had stuck a pitchfork into his right forearm. Since then he had had difficulty in flexing and extending the arm. Six years before, he had struck the right elbow on a sharp steel projection, causing intense pain and residual soreness. Later, a "lump" developed in the region of the joint, and for five years pain had been a symptom. Painful locking had taken place frequently during the preceding three years. Flexion or extension, when forced, caused unusual pain. The right elbow was 5 cm. greater in circumference than the left.

The roentgenogram (Fig. 9) revealed multiple bodies of the right elbow. On June 7, sixty-five rounded loose bodies were removed from the joint. The largest was about 2.05 cm. in diameter, the next largest about 2 cm. in diameter; the other bodies were nearly all about 6 mm. in diameter. Small cartilaginous-tipped pedicles were evident at several points on the synovial membrane. There was evidence of chronic irritation of the joint.

A letter from the patient, dated September 3, 1921, says that the arm is painful only as forecast of cold or stormy weather, and that he can work nearly all the time, but believes that bodies are again in the joint.

Case 12 (A240416).—J. M., a farmer, aged twenty-four years, with

osteochondromatosis of the right elbow, was examined July 30, 1918. The patient complained of pain in the right elbow of nine or ten years' duration, and limited motion of four or five years' duration. Two years before, a small "knot" appeared posteriorly. All symptoms had been gradually progressive. There had been no redness. The roentgenogram revealed multiple calcified bodies typical of osteochondromatosis.

On August 1, 107 bodies ranging in diameter from 2.1 to 0.15 cm. were removed from the right elbow joint (Fig. 10). It was demonstrated that they originated in the synovia.

Case 13 (A86594).—J. K., a farmer, aged twenty-three years, with osteochondromatosis of the right elbow, was examined March 12, 1917. The patient complained of pain in the right elbow, which he had first noticed ten months before, while shoveling dirt.

The clinical findings in the joint were negative except for incomplete extension of the arm. Mercury ointment was prescribed.

February 3, 1918, the patient returned to the clinic. For three months he had noticed swelling around the joint. Pain, especially in moving the joint, had continued. The roentgenogram revealed multiple bodies. On January 10, twenty-one loose osteo-cartilaginous bodies were removed from the right elbow-joint. The site of origin was not determined at this time, although it was thought that the bodies were due to osteochondromatosis.

January 9, 1923, the patient again returned to the clinic. He had been fairly well until seven or eight months before, when the right elbow became more painful, especially on use. In front of the medial condyle a movable, hard body could be felt. On January 15, the ulnar side of the elbow was opened anteriorly and a pedunculated body 7 mm. in diameter was found attached to, and evidently having its origin in, the synovial membrane on the anterior wall of the capsule. Free bodies could not be found.

Case 14 (A414987).—S. P., a woman, aged sixty-six years, with osteochondromatosis of the left elbow, was examined January 11, 1923. The patient complained of a tumor in the left elbow. About twelve years before she had fallen on the left elbow, and swelling and some pain had ensued for a week. More or less swelling remained, but there was no pain. In November, 1922, it was noticed that the joint was gradually enlarging. Enlargement had increased rather rapidly, with dull ache, but little pain. Two weeks before, a thin, brown, watery fluid had been aspirated.

In the region of the left elbow there was a large fluctuating mass.

There was no tenderness, but marked crepitation was felt on motion of the distorted joint. Besides osteochondromatosis, the possibility of a neuropathic joint was considered, but careful neurologic examination failed to reveal any basis for the latter possibility. The Wassermann reaction was negative. There was a tardy left ulnar nerve palsy from the changes at the left elbow-joint. The roentgenogram revealed multiple large bodies of the joint. On January 18, 1923, three large loose bodies were removed under local anesthesia. The condition of the synovia was typical of osteochondromatosis (Fig. 1). There was an abundance of fluid in the joint.

Case 15 (A393209).—C. W., a farm laborer, aged thirty-three, with osteochondromatosis of the flexor tendon sheath of the middle finger of the right hand, was examined in June, 1922. Four years before, the middle finger of the right hand had been split and dislocated backward by a baseball. Six months later stiffness came on, and about one and one-half years before examination at the Clinic a hard, movable lump near the base of the middle finger had been noted. At operation, under novocain, five cartilaginous tumors were removed from the flexor tendon sheath (Fig. 11). No definite bony or fibrous attachment was discerned, and the bodies slipped out easily when the tendon sheath was cut. The bodies were all about 1.5 cm. in diameter.

Case 16 (A38869).—J. F. H., a machinist, aged twenty-eight years, with loose bodies in the left knee, was examined June 14, 1910. Three and one-half years before, stiffness and soreness had developed in the left knee. There was no history of injury. Locking was frequent. On June 16, about 200 small loose bodies were removed (by Judd) from the left knee-joint. Unfortunately, these were not preserved for study, and the roentgenograms of the case were destroyed. The large number of bodies and the age of the patient leads us to believe that this is a case of osteochondromatosis, but in the absence of definite proof we have classified it as doubtful.

Case 17 (A123360).—W. L. M., a farmer, aged twenty-eight, with probable osteochondromatosis of the right knee, was examined January 26, 1915. Eight years before, he had been kicked in the right knee and had limped for several months. Occasional locking followed. Several bodies had been removed from the joint elsewhere.

Operation was advised, but was deferred until July 14, 1921, when sixteen loose osteocartilaginous bodies were removed, eight from the posterior compartment through posterolateral incisions, and eight from the anterior compartment. It was difficult to determine the exact site of origin, but the operative record said that the bodies appeared to

originate in the synovial membrane and possibly also in the intercondylar notch.

Case 18 (272634).—I. K., a farmer, aged twenty-six years, with probable osteochondromatosis of the right elbow, was examined May 29, 1919. Seven years before, the patient had fallen and injured his right elbow. Since then the elbow had pained, especially on throwing, and there had been frequent lockings. Limitation of motion was noted. At the time of examination some crepitus was present in the right elbow-joint, but no pain. He had had some rheumatic pain in the knees.

The roentgenographic examination revealed multiple loose bodies of the right elbow, and on December 11, 1920, twelve bodies were removed. There was marked hypertrophic arthritis. The pathologist reported osteocartilaginous loose bodies (Table 1).

DISCUSSION.

The chief interest attached to this subject is the etiology. In the review of the records that we have at hand in the Mayo Clinic of loose bodies in joints, we have often been at a loss definitely to classify them. We have definitely attributed fifteen to osteochondromatosis. The appearance of the synovial membrane is characteristic, and the cartilaginous bodies can be seen in various stages of development. The opportunity is not always afforded of inspecting the synovial membrane as, for instance, in Case 9. In this case, as in a few others, the number, size, shape, and consistency of the bodies, and the comparative youth of the patient, led us to believe that the marginal osteophytic lipping was in reality a part of the osteochondromatosis. The point of reflection of the synovial membrane from the joint in the adult is the point of differentiation in fetal life. It certainly is a most favorable situation for a disarrangement of cells that may later in life take on properties which are not normally relegated to cells in this situation. It is reasonable to believe, therefore, that the marginal lipping is in reality due to activity of these cells in the folds of the synovial membrane at the marginal recesses of the capsular cavity.

We have accepted as osteochondromatosis of the synovial membrane only such cases as we have been able to prove by visual inspection (twelve cases), or cases which, by the number of bodies, their size, shape, and consistency, and so forth, seemed to fulfill the conditions (three cases). In three others (Cases 16, 17 and 18) we believe the bodies were due to osteochondromatosis, but we have hesitated to classify them definitely as such.

CONCLUSIONS.

1. Osteochondromatosis of the synovial membrane is one of the causes of osteocartilaginous loose bodies in the joints, and probably the sole cause of the bodies in the bursae and tendon sheaths.

2. We believe that the condition should be classified as a benign neoplasm. Trauma is a secondary factor.

3. One of our cases was associated with a malignant chondrosarcoma in the lower end of the femur. No malignancy was discovered in the knee-joint.

4. Removal of all the bodies relieves the patient in the majority of instances. We have not found amputation or resection necessary for synovial osteochondromatosis.

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THE EVOLUTION OF FRACTURE TREATMENT, OR WHAT HAVE BEEN THE REAL CHANGES

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In reading over the chapters on fractures in the works on surgery which have been printed during the past hundred years, it is interesting to note the very clear description that is found in the text in practically all of these books on the points which are present-day essentials in the management of fractures. The variety of fracture, the direction of displacement of the fragments, the mode of repair, the symptoms and prognosis are in a general way the same as are found in modern text books. It appears they have been rewritten and rewritten from time to time through all these years, with very little change.

The following quotations are taken from some of these books printed from sixty to eighty years ago, bearing upon the general subject of fracture treatment:

Regarding fracture-dislocation at the shoulder joint, Charles McBurney in "Annals of Surgery," Vol. XIX., 1894, says: "The injury which is the subject of this paper has received careful study from numerous observers since a very early period, and the attention bestowed upon it has been much greater than I was at all aware of until, with the invaluable aid of Dr. Charles N. Dowd, I was able to study its history. It is interesting to note that so long ago as fifty years before Christ, Pasicrates described the injury, recommending reduction of the dislocation first and treatment of the fracture afterwards, and Aristion, Heliodorus, Paul of Egina, Guy of Chauliac, and others, all recognized the importance of the injury and the difficulties encountered in its management. In 1839, Sir Astley Cooper, who was fortunate enough to meet with three cases, when reporting them, says, 'Every intelligent, well-informed surgeon will now confess that no knowledge or exertion of skill could have prevented the deformity and loss of the natural motion which results from this formidable accident.'

"This statement is certainly not supported by subsequent history, for, owing to fortunate ease of reduction, a number of cases have been successfully treated.

"In 1843, Riberi reported a case which he had treated by passive motion so as to establish a false joint at the point of fracture, the

dislocated head of the humerus being left unreduced. The method of treatment made use of in this case is still known by the name of Riberi.

"In 1852, Richet read before the Surgical Society of Paris the history of a case of fracture of the neck of the humerus with dislocation of the head, and a very full discussion of the subject followed, and in 1884, appeared the thesis of Oger, in which were collected and compared the records of eighty cases, and many facts in regard to the frequency of the injury, its pathology, and the results which follow it were presented.

"A most satisfactory discussion of the subject is to be found in the book on dislocations by L. A. Stimson, and in the Revue de Chirurgie, 1892, is a very complete paper by Poirier et Mauclaire, in which fracture of the humerus with dislocation of the head is studied at length, and additional cases are given.

"The accident is a rare one, for a careful extended search has revealed the records of only 117 cases, and no single observer has met with more than five. Of course, there are many unreported instances."

The following is a quotation from a work published in 1845 by Mr. James Miller, Professor of Surgery in the University of Edinburgh, Scotland:

"The treatment of fracture may be said to consist of three parts, reducing the fragments to their proper position, retaining them so, and preventing redisplacement or other evil consequences.

"Reduction is effected without force and gradually. With one hand, the limb is grasped on the distal aspect of the fracture, and extension made gently yet determinedly, the limb being at the same time placed in such a position as to ensure relaxation of these muscles most likely to oppose this movement.

"Retention is effected by the fulfillment of two obvious indications: First, by keeping the limb in such a posture as shall relax those muscles which we know to be the most busy and powerful agents of displacement. Secondly, by applying mechanical means externally to the fractured part, adapted to prevent motion. These mechanical appliances are termed 'splints'. They are variously constructed, but all with one object in view—to rest lightly and easily on the part and yet be successful opponents of motion in the fragments. They may be made of iron, as the double inclined plane so useful in most fractures of the leg; or of wood, as the ordinary splint for fractured femur and fractured fibula; or of pasteboard, as in fracture of the bones of the forearm; or of leather, like the splints found so useful in the chronic affections of the joints: or of soft materials saturated with gum or starch, which become tightly adherent as well as accurately fashioned to the part.

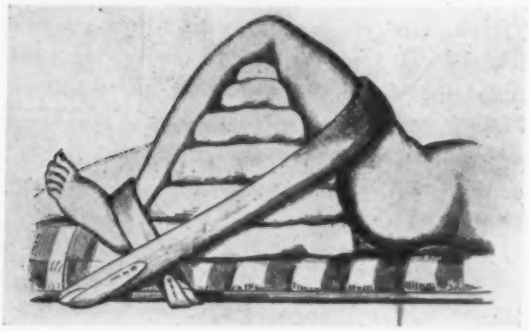


FIG. 257
1856
FIG. I

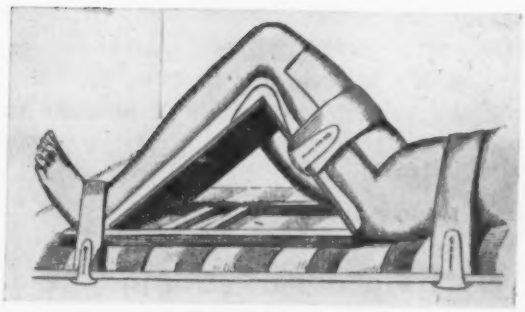
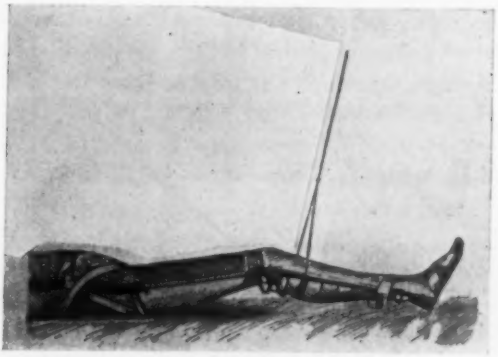


FIG. 258
1860
FIG. II



Nathan R. Smith.
FIG. 281
1863
FIG. III

"The wood, iron, and pasteboard splints are those most commonly in use, and most generally applicable. They are retained by bandaging, uniformly and evenly applied, not so slack as to admit of any motion between the fractured ends, and not so tight as to endanger undue pressure or constriction, either on any part or on the whole limb. The first application of the bandage should always be rather too slack than otherwise; allowance being made for the swelling and engorgement which are certain to occur, to a greater or less extent, in the course of a few hours. The splints should invariably be of sufficient length to command the neighboring joint or joints; otherwise, by rotation, voluntary or involuntary, redisplacement will certainly be effected.

"Daily dressing, manipulation and movement may, in the eyes of the ignorant, express great care and anxiety and even skill on the part of the practitioner; but in the minds of the well informed, the same evidence convicts him of glaring malapraxis. It is most essential for due advancement of the process of reparation that the uniting parts should be placed and retained in a state of absolute repose. Watchfulness and meddling are widely distinct. We can not satisfy ourselves too often, from examination both by sight and touch, on the outside of the apparatus, and also by regard to the general state of the system, that all is advancing favorably at the site of fracture; but at the same time, we can not too seldom interfere with the position of the limb when this continues accurate and easy."

In 1834, Miller says, "An attempt has recently been made to supersede almost all other splints by those of gum or starch. This form of splint is applied in the same way as recommended in the treatment of chronic affections of the joints. It is of easy adaptation, looks well when applied, and is promising of much benefit, forming a tight, accurately fitting, unyielding case, in which the broken bone lies securely imbedded. Under certain circumstances its use is in all respects admirable, but its indiscriminate employment tends manifestly to injury. During the first period of the treatment of severe fractures it is quite unsuitable, for considerable swelling must occur, requiring proportionate slackening of retentive apparatus which ought consequently to be light and easily changed. Further on in the case, when the swelling has reached its acme, and has begun to subside, it is still inappropriate; if applied today, the limb will have shrunk so far by tomorrow that the apparatus has ceased to be retentive. If then employed at all, it must be almost daily renewed, and that is foreign to the nature of the application. It is only during the later periods that its use becomes judicious. When the time for inflammatory swelling has gone by, and when further decrease of the

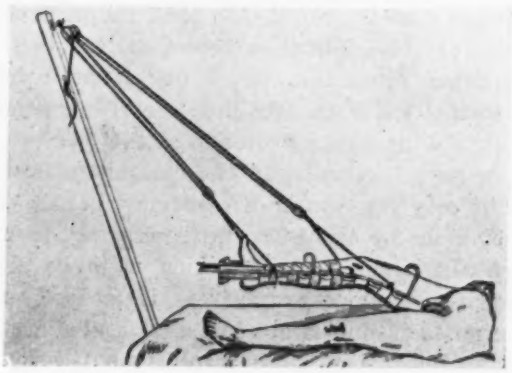
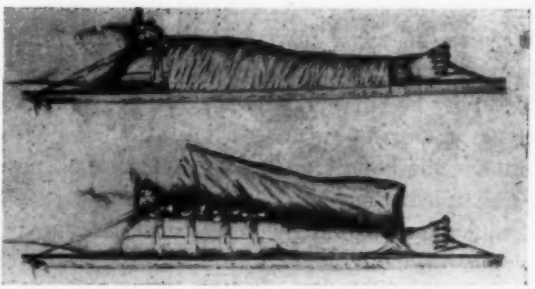


FIG. 80
Hodgen's Splint
FIG. IV



DeSault's Fraction Splint from James Syme's, 1842
FIG. V

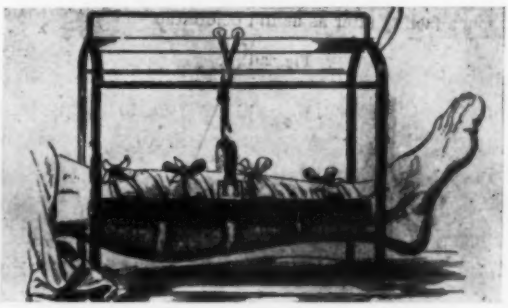


FIG. 292
1863
FIG. VI

more or less swollen limb is improbable, then the permanent, fixed and unyielding nature of the application ceases to be detrimental and becomes most salutary. If used sooner, it ought not to be in mass, but after bisection, so that the apparatus then comes to resemble two neatly and closely fitting splints of the ordinary kind."

In 1845, Miller says further: "In the case of an obstinately 'rising end' of a bone, it may come to be a question whether or not pressure should be employed, as by compress and bandaging, to force it into its normal position. In general, this question is to be answered in the negative. The pressure, unless very severe, is not likely to succeed, perhaps may fail even then, and is apt to occasion ulceration or sloughing of the integuments, or abscess more deeply seated; events all most unfavorable to the process of cure. It is better, by attention to position, to relax the muscles which are causing the displacement and to bring the other fragment higher in its level, until a smooth and continuous readjustment shall have been thus attained. Most certainly, when the rising of the end is only apparent and not real, as in the case of the clavicle, nothing can be more unwarrantable than the application of pressure to the part which is in truth undisplaced."

In 1843, Miller may be further quoted: "In treatment the paramount indication is reduction, and can not be attempted too soon. It consists of extension to move the bone from its normal position and bring it on a plane with the articulating surface it has left; counterextension to steady the latter part and admit of extension being satisfactorily effected; and coaptation to replace the surfaces in apposition. If the patient be seen immediately after infliction of the injury, yet faint, with all his frame prostrate and relaxed, and incapable by any effort of throwing any part of his muscular system into strong resisting action, reduction may be expected to be comparatively easy. The surgeon is able to cope with the accident single-handed. In the case of the shoulder, for example, he takes hold of the elbow with his right hand, and gently extends the arm, while, with the fingers of his left hand, he pushes the head of the bone toward the glenoid cavity. After moderate extension he makes a sudden, combined, jerking movement, and usually succeeds."

It was early recognized that all fractures of the upper third of the femur should be treated by elevating the lower end of the femur, either with the knee flexed at a right angle or at some angle. Figures Nos. 257 and 258 show steps in the development of this idea. They were taken from H. H. Smith's book; volume 1, published in 1863. Figure 281 from the same book, a description of which was published in Golden's Baltimore Medical and Surgical Journal in 1833, and which was also published as per the description, in 1849, is the design of Nathan R.

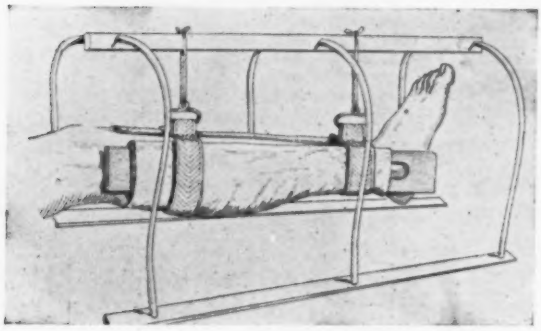


FIG. VII

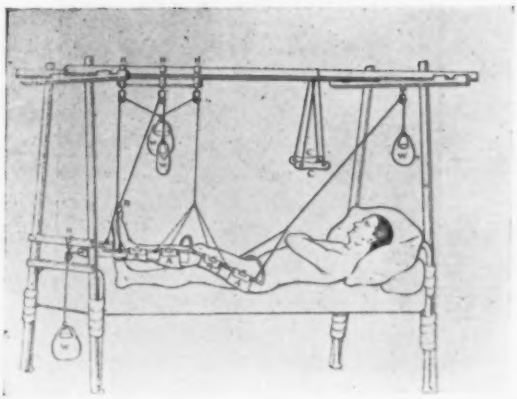


FIG. VIII
The above is the Blake frame.

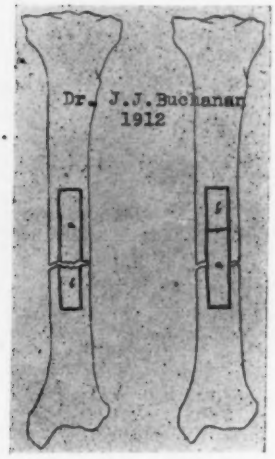
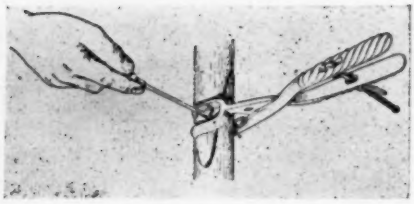
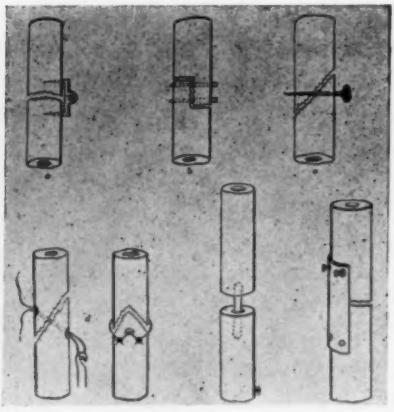


FIG. IX



Peter's Forceps (from Cheyne and Burghard.)
FIG. X



Different Methods of Uniting the Ends of a Long Bone.
FIG. XI

Smith of Baltimore. Further development of the idea may be seen in Figures 282 and 283, as used by Nathan R. Smith and published in H. H. Smith's Surgery, volume 1.

After this time Hodgen began using a modification of this idea, as is shown in Figure 80, and is a further use of Buck's extension with elevation of the extremity with the knee in slight flexion.

I think it is proper to submit for your inspection Figure 292 from H. H. Smith's Surgery, an illustration of De Sault's apparatus, as well as the Cheyne method of suspending the leg, both of which are for the purpose of treating fractures of the leg by suspension and elevation.

Must we not see in these various methods of treating fractures of the lower extremity all of the elements of refinement and of practical benefit, the evolution of which may be shown in Figure 127.

It will be of interest to the younger members of the profession to read the list of papers copied from H. H. Smith's bibliographic index, an exhaustive list of all articles printed on the subject of fractures, and, indeed, every surgical subject previous to 1863.

If the list of apparatus is studied, one must come to the conclusion that there are very few new principles in the construction of the modern apparatus, with the exception of making them of metal and sanitary, rather than of wood and fabric.

I submit several illustrations showing the earlier methods of bone fixation. Dr. J. J. Buchanan of Pittsburgh was one of the earliest users of bone grafts, and the illustration shown was published in 1912, but had been used a number of years previous to that date.

The two other illustrations in this group represent practically all of the other methods of fixation.

You must also be reminded of the methods of fixation introduced by Professor J. William White, as well as the Parkhill plate.

What is the Thomas' ring but the ambulatory method shown in De Sault's fracture splint from James Sims, 1842? Dr. Horner, of Philadelphia, as early as 1826, used this method of treatment, as may be seen in Figure 274 from H. H. Smith's book.

ADHESIVE PLASTER.

Cheselden, in his Anatomy, published in 1740, speaks of the use of adhesive plaster, the late Dr. S. D. Gross advocated its use in 1850, and Dr. J. N. Quinbey wrote a paper on this subject in 1867. (Judson.) From that time to the present date it is increasing in favor.

The following quotations are taken from H. H. Smith's Surgery, published in 1863:

"Passing over the ancient methods of preserving extension when it has been made by the hands, I shall limit this account to that obtained

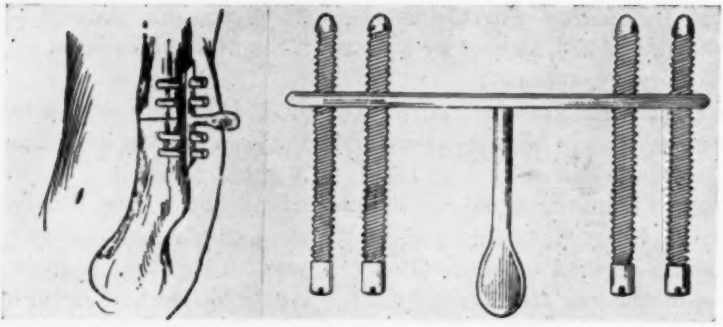
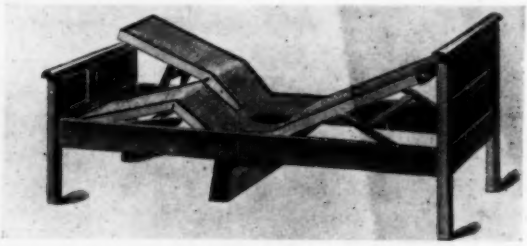


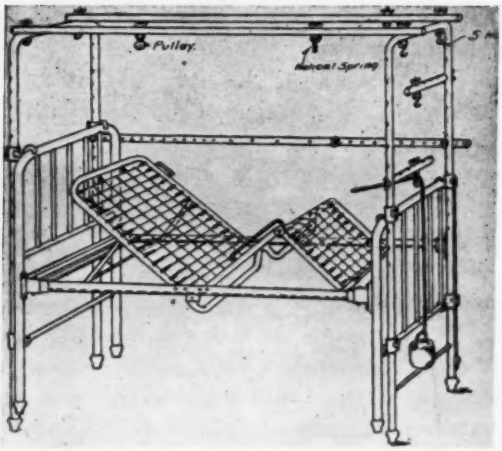
FIG. XIII FIG. XII

The above method of securing fixation of fractures is that of J. William White of Philadelphia, and was used by him. It is evidently one of the earliest methods of fixation.

FIG. 292



McCurdy's Fracture Bed, 1888.
FIG. XIV



Devised by Dr. Nathaniel Allison of St. Louis.
FIG. XV

The evolution of the fracture bed may be briefly illustrated in the two figures above.

by the use of adhesive plaster, the utility of which has been so marked as to bring forward several claimants for the suggestion, as Gross and E. Wallace of Philadelphia, and Crosby of New Hampshire. Of the priority of these claimants it is difficult to decide, but it was certainly but little known or used in Philadelphia until Wallace called attention to it.

"In few fractures have surgeons suggested more varied plans of treatment than in those of the femur. Without attempting even to mention all of these, I would advise the inexperienced practitioner to take the simplest that is adapted to the case, and to shun all the patented, costly, and usually very attractive forms of apparatus sold by inventors and their agents.

"Then, to prevent any recurrence of the displacement from muscular action, the straight position of the entire lower extremity maintained by splints, with good extension and counter-extension, is the best plan of treatment.

"Counter-extension. This, like extension, is best preserved by attaching the limb to the splints by means of adhesive strips, as suggested by Gilbert, of Philadelphia."

"Gaston of South Carolina has also employed counter-extension by means of adhesive plaster by warming a strip two inches wide and applying it closely over the groin, spinous process and crest of the ilium as far as is possible, carrying the other end of the strip through the top of the external splint while a second is made to adhere to the trochanter major, and thence up and behind as far as possible before passing to the splint. By these attachments he claims to gain two firm points of attachment, owing to the close adherence of the skin to the bones at these points."

The following extract taken from an article written by Joseph A. Blake clearly shows that the so-called Balkan frame was designed by him:

"On assuming charge at Hospital B, American Ambulance, Juilly, Seine et Marne, in February, 1915, we were immediately confronted with the practical difficulties of dressing complicated compound fractures of the extremities. From the standpoint of the surgeon these dressings were time-consuming, difficult, and unsatisfactory; to the patient they were long-drawn-out ordeals of pain. With the limited personnel at our disposal it was obvious that we must evolve a more satisfactory method of handling these cases. At this time we were receiving our wounded by ambulance direct from the French field hospitals."

We believe that the so-called Balkan frame should be called the Blake frame in justice to Dr. Blake's work and for the reason that it is difficult, so far as I have been concerned, to trace the origin of the word "Balkan." (Fig. VIII.)

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TREATMENT OF TUBERCULOSIS OF THE KNEE JOINT IN CHINA

RESUME OF PAPER PRESENTED AT THE MEETING OF THE CHINA MEDICAL MISSIONARY ASSOCIATION, SHANGHAI, CHINA, FEBRUARY 14, 1923.

BY THORNTON STEARNS, M.D.

Surgeon of the Hospital of the Shantung Christian University. Tsinan, China.

TREATMENT of joint tuberculosis so as to eradicate the disease, and, at the same time, obtain a satisfactory functional result is one of the most difficult surgical problems. This is especially true in China at present, for the reason that most cases present themselves for treatment only in the advanced stages, and for the reason, also, of the poor economic condition of the people, the scarcity of hospital beds, the absence of social service to assist financially and of visiting nurses to do follow up work, and also the lack of convalescent homes. In most cases, the problem resolves itself into a question of giving the patient a functional result in order that he may earn his living as early as possible.

In this paper, there is considered the treatment of tuberculosis of the knee. The desired end result is a bony ankylosis, which may be obtained by conservative means which require an extensive period, or by a surgical procedure requiring a much shorter time. One of the drawbacks to conservative treatment, aside from the uncertainty of obtaining a bony ankylosis, is the length of time necessary. A fibrous ankylosis as a functional result for a working man is not satisfactory because of the slight motion and the pain due to adhesion, and a resection of the joint must be performed in the end. Resection of the knee joint for tuberculosis is an old, tried, and satisfactory method of treatment in the West. Its application has certain definite, fixed conditions, but owing to the late stage in which disease is usually seen in the East and to the poverty of the people and the necessity of getting the patient back to work as soon as possible, as well as to the lack of charitable assistance and of hospital space, the conditions in the application of this surgical measure are different. It is from this point of view that we present the subject.

The subject of tuberculosis of the knee may be divided into three stages: early, intermediate, and advanced.

1. *Early stage.* Before marked synovial or joint changes have taken place, the diagnosis and treatment of the knee may be very difficult, and it must be remembered that the condition under which diagnosis must be made here in the East is different from that in the West. The two may hardly be compared. There is so often the history of injury that one may look upon the condition as a chronic traumatic arthritis. With the exclusion of gonorrheal urethritis or syphilitic infection, one must be suspicious of tuberculosis. With the positive diagnosis of tuberculosis made, what may be the treatment in this early stage? The treatment is difficult because the temptation is to be conservative where perhaps radical methods should be chosen. There must first be considered the economic and social condition of the patient and the limitation of bed space. In all adults, except in the well-to-do, in whom there is no pulmonary process, we believe that resection of the joint should be performed as soon as the diagnosis is made. In the well-to-do, when good home conditions are available, and an indefinite period of rest may be relied upon, we would try conservative treatment (cast or Thomas splint) so long as there appears to be no progression of the disease. If, after a reasonable period, nine months or a year, there is no improvement or evidence of return to normal, or if there is evidence of progression of the process, resection of the joint seems to us to be clearly indicated. Even with these adults who can be placed under good economic conditions, it is a grave question in our mind whether resection of the joint should not be advocated as soon as the diagnosis is made. In children, in this stage of the disease, we should carry out the conservative treatment unless there were signs of the failure of the general condition.

2. *Intermediate stage.* In the presence of marked synovial thickening, moderate limited motion, the picture, considered with a history of remission extending over months or a couple of years or more, is typical. The diagnosis is fairly simple. However, there is a monarticular syphilitic synovitis, probably the beginning of a Charcot's joint, which clinically may be taken for a tuberculosis of the knee in an early or intermediate stage. Two such cases have been encountered. The synovial thickening and limitation of motion were less than in the tubercular form. There was no evidence of fluid in the joint. Positive Wasserman confirmed the diagnosis. In this intermediate stage of tubercular infection, without regard to the economic condition, and when the pulmonary condition is good, we believe that prompt resection

should be advised. In children, when the home condition is good, a period of a few months of conservative treatment under close observation should be given trial. When home conditions are poor, resection should be performed at once. We believe that these moderately advanced cases progress from bad to worse, and, therefore, the earlier resection is done, the better.

3. *Advanced stage.* It is in this advanced stage that one sees the greatest number of cases in China. From the point of view of treatment, they present the greatest problem. The intermediate and advanced stages more or less merge into one another. The border line is not sharply defined. Many of the advanced cases, particularly with sinuses, do not leave room for doubt as to their classification. These cases are of long duration and come to the hospital as a last resort. With experience in only one case with sinus, and in which the condition was excellent, and in which resection gave a fairly good result, we feel encouraged and willing to attempt radical treatment in advanced cases with sinuses, realizing the seriousness of resection in cases with sinuses and in which there is a secondary infection present. Without resection, it would have been a question of amputation or a very long period of rest in the hospital, with the indefinite hope that the sinus would heal and that resection could then be resorted to. In spite of the greater risk, it gave this patient a good leg in a reasonable length of time. Resection in this case needs more extensive trial or else must be urged because of the lack of proper economic conditions before it can be advocated. When the method of mortising the two bones is used and no foreign body put in for retention, and a good application of cast is made, the danger is less than in the case above, for in this case a steel plate was used to unite the two bones. There may be in these cases a severe local infection with complete breaking down of the wound, but with careful treatment of the wound, if the general condition of the patient is good, the infection will subside. When there has been a separation of the skin edges, and when the granular tissue has reached the level of the skin and has become healthy, the pin point skin grafts will hasten the wound closure. In those cases where the patient's condition is not good, and if there is pulmonary complication of even mild form, the amputation is advised. In children, there is the same choice, although when the general health is good, we would advise a few months of general treatment to obtain improvement if possible, and to then attempt a resection. If, on the other hand, after six months of hospital treatment, there is no improvement, amputation should be done.

This should be done earlier if there are signs of failure on the part of the patient.

These principles of treatment may seem somewhat radical as compared with those of the West, but the difference in economic conditions of the people and the scarcity of beds must be considered. During a visit in China in the spring of 1922, Dr. E. G. Brackett became very strongly of the opinion that in the East, much more radical methods must be used because of these conditions and the necessity for the patient to be early restored to earning capacity.

OPERATIVE PROCEDURE.

Preparation of the leg on two successive days was done in all cases. A horse-shoe incision, convexity downward, flap of skin and superficial fascia dissected upward; patella removed; the joint thoroughly exposed; the synovial membrane with its tubercular granular tissue removed but no attempt made to dissect it all away; slices as thin as possible were removed by the saw from the tibia and femur. These pieces were cut so that an angle of about twenty-five degrees from full extension was formed when the bony surfaces were held in contact. In six cases, holes were bored obliquely on each side through the two bones, and heavy kangaroo tendons threaded through and tied. In one case, an intramedullary bone graft was placed, uniting the two bones firmly. In one case, thin slices were sawed from the condyles and chiseled from the head of the tibia, leaving a wedge which fitted snugly into a notch cut between the condyles. An angle of twenty-five degrees from the full extension was easily maintained on account of the snugness with which the wedge and notch fitted into each other. This is the mortice method. After the wound was sutured, a plaster cast was applied, extending high on the thigh and including the foot. A hole was cut through it to observe the wound.

In four cases of plating in which casts were changed before leaving the hospital, there was bony union in three, at the end of five months, and a fibrous union in one, at the end of seven. In five cases where only kangaroo tendon was used and the cast changed before the patient left the hospital, there was bony union in three, at the end of six months and fibrous union in two, at the end of eight. In five cases, plates were used to stabilize the two bones. All of these plates had to be removed in the course of time, in some, under local anesthesia. Sinuses had formed in all of these five cases. In the case in which the intrame-

dullary bone graft was used, and in the case in which the mortice method was used, no sinuses occurred.

From these cases, it is seen that joining the bones with the kangaroo sutures gave better results, but took a longer period. Sinuses always occurred when the plates were used, but bony union took place more quickly. In one case where kangaroo sutures were used, there was still fibrous union after ten months, and a second operation was done and a plate put in position to hold the bones in apposition.

In resection in children, one cannot be too careful about avoiding the epiphyses. Just enough cartilage should be removed to expose the underlying bone. If the disease is so extensive that it involves the epiphyseal line, there must necessarily be an arrest of growth, and a shorter, useless limb. In this case, amputation is advised.

SUMMARY OF CASES.

Records are of six cases, all of which are well and have a good functional result at a period ranging from nine months to four years after operation. From three other cases no reply has been received, but their immediate operative result and general condition would warrant an opinion that these also were well. One case now under observation and in good general condition has almost firm union and is promising a favorable result. The report of one case received indirectly gives complete healing and firm union but patient experiences some difficulty in doing her work. This case was the one which had a sinus at the time of resection. One case reports a sinus at the end of a year, but this is not particularly uncommon, and if the general condition is good, there is no reason why the sinus should not be expected to heal. One case now in the hospital has not yet developed a firm union after a period of fifteen months. There are, therefore, six positive cures, three probable cures, one case improved, two cases under observation with favorable outlook. One case at a distance, of which complete records are not available, has still a sinus, but apparently union is taking place.

CONCLUSIONS.

1. Both with adults and children in poor economic conditions, with no pulmonary contra-indication, resect joint as soon as a positive diagnosis is made.

2. In adults, during the early stage, with good economic conditions, conservative treatment (splint or cast) may be used as long as there

seems to be no progression of the disease. (Even here, we are inclined to advise resection as soon as diagnosis is made.) In children, in the early stage, with economic and home conditions good, the conservative treatment should be given a trial. Should there be no improvement after nine months or a year, or should progression of the disease be evident, resection is to be advised, provided there is no pulmonary contra-indication.

3. In adults, with general condition poor, or with incipient pulmonary tubercular process, amputate above the knee.

4. In children, in poor general condition or with incipient pulmonary tubercular process, conservative treatment should be attempted for about six months. Should the general condition not improve, amputation should be advised.

5. When the general condition of the patient is good, the presence of a sinus from the joint is not a contra-indication for resection of the joint. It is realized that this is a radical step, and not without danger, but under good operative conditions, it may be attempted in order to save the patient time, and, considering conditions in this country, to save bed space. This is advised with the consideration that conservative treatment gives no sure hope that the sinus will heal, and also in consideration of the fact that, should it heal, resection would be indicated.

6. The mortising of the two bones is the operative choice.

7. The joining of the two bones together by bone plates gives a quicker bony union than uniting the bones with kangaroo sutures passed through holes upon the two sides of the leg.

BILATERAL ASYMMETRICAL CESSATION OF GROWTH OF UNKNOWN ETIOLOGY IN EPIPHYSES.

BY R. D. SEVERANCE, M.D., ROCHESTER CLINIC, ROCHESTER, N. Y.

We wish to place on record a case presenting an asymmetrical bilateral cessation of growth of the metacarpals. The deformity was first noticed in the left hand about one year ago, shortly afterward in the right: both have progressively increased. It could not be definitely ascertained that there was an interval in the onset in the two hands. There is no history of injury, disease, mal-nutrition, or any other etiologic factor. Patient has had the usual uncomplicated children's diseases. The mother and father are alive and well. No hereditary influence was obtainable in the history.

PHYSICAL EXAMINATION.

Normal, healthy, well developed girl of ten years, presenting no abnormalities except the hands. *Left* hand: index and fourth fingers are of the same length—apparently normal. Third and fourth fingers appear shortened. The distal phalanx of the thumb also appears shortened. The knuckle line is irregular when the fingers are extended; this is markedly increased when they are flexed. *Right* hand: Thumb and index finger appear normal. Third, fourth, and fifth fingers show increasing shortness in that order. The knuckle of the index finger is very prominent; others recede progressively to the fifth. The soft parts are apparently well developed and normal in contour and size. No scars or limitation of motion at any of the joints. The function of the hands is not disturbed.

The accompanying table and x-ray picture will show the exact relationship of the various bones. Attention might be called to the relative increase in size of the distal extremities of the affected metacarpals and the absence of the epiphyseal lines. The thickness of the cortex and the diameter of the diaphysis seem to be increased.

Darbois & Chevallier* report a case of cessation of growth of the left fifth metacarpal of unknown etiology. In their case, the left fifth meta-

*Darbois & Chevallier—Bull. et Mem. Soc. de Radiol. de Paris, 1910, 11, 286-289. Brachymélie congénitale du cinquième métacarpien gauche.

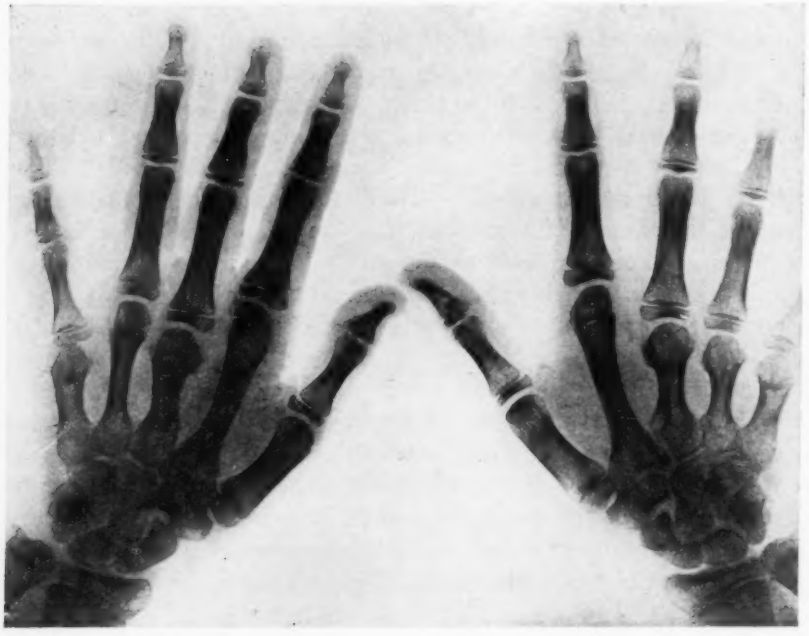
carpal was 12mm. shorter than the right. They also noted that the distal extremity was enlarged, the diaphysis thicker, and the medullary canal increased in diameter.

We feel that this case represents a disturbance of growth—in fact a cessation of growth—of the distal epiphysis of the affected metacarpals. We are unable to offer any plausible theory for its cause.

TABLE OF MEASUREMENTS FROM X-RAY (Millimeters)

Digit	Length				Width of Extremity				Width of Shaft	
	Finger		Metacarpal		Distal		Proximal			
	L	R	L	R	L	R	L	R	L	R
1st	47	50	39	41	12	12	13	13	10	10
2nd	78	78	58	57	12	13	17	18	8	8
3rd	*89*	*86*	*40*	*40*	*16*	*16*	*13*	*13*	*8*	*7.5*
4th	85	*81*	45	*37*	11.5	*13*	11.5	*11*	6	*6*
5th	*64*	*64*	*35*	*34*	*12*	*13*	*13*	*13*	7	7.5

Foot Note—Measurements recorded in italics are of the affected digits.



SOME ETIOLOGICAL FACTORS IN SURGICAL TUBERCULOSIS OF CHILDHOOD.*

BY WALLACE H. COLE, M.D.

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ALTHOUGH the etiological factors in bone and joint tuberculosis are in the main well worked out and understood, it is not unwise at times to review them in the light of experience and see whether the general teachings are still corroborated by later series of cases and whether anything new can be added to the facts already known. With these ideas in mind a study was made of the histories of all the cases of surgical tuberculosis which had been admitted to the Minnesota State Hospital for Crippled and Deformed Children since 1914, and the results of this study form the basis of this paper. Nothing strikingly new was discovered, but enough interesting data was compiled to warrant its being used for such a purpose. Two hundred and five histories were examined, this being the number of cases admitted since the time indicated, but only 193 of them were found to contain enough data to allow them to be included in most of the studies.

There is, of course, only one actual cause of tuberculosis anywhere in the body, and that is the tubercle bacillus. Both the human and bovine types infect the human body and have been isolated either alone or together from infected bones or joints, but the percentage of each is far from constant and varies greatly in the different series that have been worked out and reported. The chief factors causing this variation seem to be the age of the patients and the geographical location of the cases studied. Fraser of Edinburgh found 60 per cent of his 70 cases to be due to bovine infection, while in Germany, France, and this country, the incidence of this type is apparently so much less that in some series it is almost nil. Fraser assumes that the use of milk from infected cows is the underlying cause for the bovine infection in his cases, and it is certainly reasonable to suppose that this factor is the most probable. In this country, however, where the milk supply is

*Read by invitation before the Consulting Medical Staff of the Lymanhurst School for Tuberculous Children, January 23, 1923.

fairly well controlled, such a source is probably of minor consideration. The report of the Imperial German Board of Health, in which an analysis of 1400 cases regardless of location in the body is given, shows the results of investigations in that country. Out of the total number of cases there were only 128 which were infected with the bovine type of bacillus, 115 of these being patients with generalized or glandular involvement. Ninety-nine cases of bone and joint tuberculosis were investigated and included in the series, and of these, 95 showed the human type of infection and only five the bovine. Recent postwar observations in Germany have, however, shown a great increase in the percentage of bovine cases, due, it is explained, to the lack of the supervision over the milk supply which was formerly present. Eastwood and Griffith in England studied 261 cases of bone and joint tuberculosis and found the human type of bacilli in 196 and the bovine type in 55. The remaining 10 cases were of an unclassifiable type. As worked out in percentages they showed that for all ages, 21.1 per cent of their cases were of the bovine type but that in the cases under 10 years of age this rose to 29 per cent, while in the cases over 10 years of age only 9.4 per cent were so infected. No bovine infection was found in any case over 25 years of age. Other investigations could be quoted, but their general trend is the same and the whole subject of the type of infection can be briefly summarized somewhat as follows:

Although both human and bovine strains of tubercle bacilli infect the human body, the former is by far the more predominant, the bovine being practically never found in the adult and, in this country at least, in never more than a small percentage of children. There is apparently no basis for the older assumption that surgical lesions are more likely to be of the bovine type, although, of course, they are predominantly found in the first decade of life, when such infection is more commonly present.

The importance of this question which might, at first glance, seem somewhat academic, is due to its bearing on prevention and control of infection. Attempts to differentiate the human and bovine types of infection clinically by tuberculin tests have never given definite or constant results and it can be stated with a certainty that this method is useless for such a purpose. In our series the results of only 22 bovine Von Pirquet tests are recorded and of these 21 were positive and one negative; however, of the 21 positive, 12 gave also a positive reaction to human tuberculin. Pathologically, no difference in the lesions caused by the two types of bacilli has ever been found.

There are several additional factors other than the question of the type of infection which must be mentioned, but a detailed discussion of

which is beyond the scope of this paper. One of these is the question of when, during the life of the individual, the bacilli get into the body. This is more definite when dealing with lesions in children, as the time element is not so important. The theory that most infections occur in childhood, even when activity is not present until later life, although borne out by certain observations, necessitates our believing that either the human type of bacilli can alone survive long periods of inactivity in the body or else that the bovine type is suppressed and superceded by the human bacilli as adult life is reached. The question of mutation need scarcely be considered.

The source of infection and the various methods by which such infection gets into the body are factors about which our knowledge is not as definite as it might be and there are several problems relative to these questions which still remain to be worked out. Tuberculous cows and tuberculous humans are undoubtedly the primary sources of infection and only by proper control of these can any headway be made in the field of prevention of further infections. The milk of tuberculous cows is known to contain active bacilli, and children who drink such milk are sooner or later going to become infected. This does not mean that active foci immediately make their appearance, but that somewhere in the body, usually in the mesenteric or bronchial lymph glands, a focus, more or less quiescent, can be found which may or may not cause trouble later. The infection enters the body, of course, through the intestinal mucosa, and either directly infects the mesenteric glands or passes into the blood-stream by way of the thoracic duct. Once in the blood-stream the bacilli may be carried to any part of the body, but probably in the majority of such cases they lodge in the trachio-bronchial glands, having passed through the lungs without causing clinical lesions. Children playing around or living in houses where active pulmonary cases are present might easily infect themselves through the same intestinal channels by bacilli which are carried into the mouth by toys or fingers. Infected dust or sputum particles after lodging on the mucous membranes of the upper respiratory tract would be swallowed and also take the same channel. Direct respiratory or pulmonary infection from inspired bacilli also occurs and there is pathological evidence to show that this may be the main portal of entry into the body. Parrot's law and the researches of Küss and Ghon have shown that the lungs of children with trachio-bronchial gland infection will, with practically no exceptions, always reveal a primary focus somewhere in the parenchyma. Frequently the course of the infection through the lung from the primary focus at the periphery to the glands can be clearly traced. These foci are usually quiescent or represented only by scars.

The tonsils can certainly transmit the infection to the cervical or deeper glands without being in themselves diseased, and undoubtedly some of the patients with early cervical adenitis who later develop active tuberculosis were infected in this way. As many tuberculous infections of various parts of the body occur with no apparent source of infection, either human or bovine, the possibility of such factors as flies, articles of food, clothing, dishes, etc., must also be counted among the infecting agents. Direct transmission of the infection from the mother to the foetus, that is, true congenital transmission, can also undoubtedly take place and with the bacilli in the body through this route there is no reason to suppose that bone and joint infection cannot later be a manifestation of such invasion. An interesting fact brought out in our series of cases is that while 24 per cent of them gave a definite history of tuberculosis in the immediate family, a similar series of the same number of cases of infantile paralysis with no tuberculous lesions showed 22 per cent with like histories. That is, the control series came within two per cent of as many positive tuberculous family histories as did the main series under consideration. On the basis of these findings, no great importance can be attached to such a history.

Given tubercle bacilli in the body, how do they reach the various bones and joints in which we later find them? The explanation is probably somewhat as follows:

A blood vessel is broken into by the infection in some primarily infected gland, usually in the bronchial group, and the bacilli are carried by the blood stream to some remote bone or joint. This apparently simple procedure must, however, be discussed more in detail. When a bronchial gland breaks down due to tuberculosis it may rupture into the bronchial tree and cause a direct infection of the lung, a tuberculous pneumonia, or it may open up some vein and discharge the infected material directly into the blood-stream. The causes of this lighting up of the infection in the gland so that it can disseminate the disease are varied, but any condition which lowers the resistance of the person may be responsible. The exanthemata, particularly measles, have long been mentioned as predisposing to surgical tuberculosis, although influenza and other acute infections are also said to play important parts. The cases in the present series are notably free from previous infections, only 18 out of 193, or less than 10 per cent, giving any history of a disease which even remotely seems to be related to the onset of tuberculosis. These 18 cases are divided among influenza (6), tonsillitis (3), acute pulmonary infection, probably tuberculosis (3), pleurisy (2), whooping-cough (1), pneumonia (1), empyema (1), and discharging ears (1).

After the infected material is emptied into the blood-stream there are three main possibilities which must be considered. In the first place, the resistance of the patient may be so great or the relative resistance so great compared to the number or virulence of the bacilli present that nothing further occurs. The infection is either taken care of in the blood itself, or after localizing is so attenuated that no clinical manifestations appear. In the second place we have the other extreme where the infection is so overwhelming that death ensues shortly afterward, due to miliary or meningeal involvement. The third possibility gives us a group into which fall the cases of bone and joint tuberculosis. Here the natural or acquired resistance is high, but a certain number of bacilli, probably bunched together in a particle of debris so that they are not destroyed in the blood as easily as isolated bacteria, lodge in or near some joint and start a localized tuberculosis. Undoubtedly some foci of this character never develop into clinical lesions by themselves but remain dormant until some exciting cause activates them.

We see, then, that patients with bone and joint tuberculosis are really a culled lot whose resistance is high, for otherwise many of them would have succumbed following the first entrance of the infection into the general circulation. We might expect, therefore, that tuberculin tests would be almost uniformly positive, and statements to this effect are made with the qualification that if the first test is negative larger doses of tuberculin will always bring it out. The Von Pirquet test was, unfortunately, the only one used in our series and the results do not show such a high percentage of positive reactions. The findings are recorded in 178 of the cases, and of these only 67 were positive, while 12 were doubtful, and 99 were definitely negative. To these must be added the nine additional cases that were positive to bovine and not to human tuberculin, as mentioned earlier. Therefore, only about 40 per cent of the cases in the series reacted positively to the Von Pirquet test.

The various theories which have been brought forward concerning the localization of tuberculous infection in or around joints are too well known to need more than brief mention here, and probably the theory of Lexer will account for most of the cases, with certain contributory causes, such as trauma, as secondary factors. Lexer's studies of the distribution of the blood vessels in growing bone showed that emboli tend to lodge in or near the epiphysis due to the presence of the end arteries and capillaries in this location, and these studies also show that in addition to this as a factor in osseous tuberculosis, the

rich vascular supply of developing bone accounts in part for its comparatively frequent involvement.

The importance of trauma as a contributory cause is very great, due to its medico-legal aspect. No definite answer can be given to the question of whether or not a certain injury which preceded the onset of a tuberculous joint is connected with that onset, but the histories are so definite in some cases that it is difficult not to believe that there is some very real part played by trauma in the etiology. Sixty-four, or about 33 per cent, of the cases in the present series gave a very definite history of such injury, and eight, or about four per cent, gave a history which was considered questionable. This percentage is larger than in Krause's series of 1156 cases, for the histories of only 23 per cent of them gave any ground for supposing trauma was related to the localizing of the bacilli. Other larger series also give lower percentages, and Whitman shows a combined series of 3539 cases reported in Germany in which only 16.3 per cent gave injury as a direct predisposing cause. Several factors must be considered in this connection, but it seems that most of the cases showing previous injury can be divided into three groups, the relative importance of which is as yet not definitely established. The first of these comprises those cases in which, due to the injury, always slight in character, there is a localized partial stoppage of the blood stream or a small hemorrhage that allows the lodging of the infected embolus or emboli present in the circulation. In the second group we have the cases in which a tuberculous focus was already present but where it was so early or so encapsulated that as yet no symptoms had been noticed, and the injury, by rupturing or stimulating such a focus, had caused activity or local dissemination. The third group comprises those cases in which, on account of an already present but unrecognized tuberculosis, some very slight injury seems severe because of the sensitiveness of the part, and therefore first calls definite attention to the disease. Here the injury cannot be considered in any way connected with the onset or course, being merely incidental.

The presence of other tuberculous lesions in cases with bone and joint tuberculosis is apparently rare and this fact can be easily accounted for if our previous supposition concerning the high resistance of such cases is true. Nine of our cases had signs of pulmonary involvement on admission, not all of them active, however. Five had, or gave a history of having had, cervical adenitis, two had tuberculosis of the eye, and there was one case each of tuberculosis of the kidney and of the peritoneum. Whether or not these conditions were secondary to the surgical tuberculosis cannot be discussed here, although there may be some etiologic factors involved.

The age of onset in the present series corresponds very closely with that usually taught and reported. One hundred and sixty-nine cases, or 87 per cent, were 10 years of age or under when symptoms were first noticed, the average age of onset in the 193 cases being 5.7 years. The earliest onset, so far as could be determined, was in an infant a little over six months of age, and there were several whose symptoms dated from the first two years of life.

The nationality of the cases investigated and the localities from which they were admitted form an interesting study, but this is, of course, only of value in showing conditions as they exist in Minnesota. Of the 205 cases, 57 per cent came from Hennepin, Ramsey, and St. Louis Counties as would be expected, for the largest centers of population are found within their boundaries. Hennepin County with the city of Minneapolis supplied 19 per cent, Ramsey County with the city of St. Paul, 15 per cent, and St. Louis County with the city of Duluth, 23 per cent. One is immediately struck with the fact that the largest percentage comes from the County which, of the three, has the smallest population. Further study, however, shows that these cases come mainly from the Iron Range and from the families of miners, the large majority of whom are foreign born. The living conditions are usually deplorable and this latter factor may, and probably does have an important bearing on the incidence of the disease. The activity of the County nurses must also be considered as a factor in determining the geographical distribution of the cases.

The nationality is definitely recorded in 148 of the cases considered and of these 47, or 31 per cent, are stated to be of American parentage; 26, or 17.5 per cent, were Finns; 14, or about nine per cent, were Norwegian; 11, or 7.4 per cent, were Swedes; and eight, or 5.4 percent were Germans, the rest being divided among 17 different nationalities, six Indians and two Negro patients being included in the series.

Of the 193 cases, 76 or slightly over 39 per cent, were of the female sex, and 117, or about 60 per cent, were males. This is a greater disparity than is usually reported, as most of the larger series show the percentage of males to be between 52 and 57 per cent. Whether greater activity and more frequent exposure to injuries is an underlying factor in this male predominence can only be surmised.

The points discussed or brought out in this paper are not new, but some of them can bear definite and repeated emphasis. Briefly these are:

1. That poor home conditions, insufficient or improper food, lack of fresh air and sunshine, and the presence of unhygenic surroundings in general seem to be as important, if not more important, than tuberculosis in the immediate family, in the etiology of surgical tuberculosis.

2. That patients of the type under discussion have a high resistance to tuberculosis infection; and

3. That tuberculosis lesions elsewhere in the bodies of such patients are comparatively infrequent.

ARTHRODESING OPERATIONS ON THE FEET.

BY EDWIN W. RYERSON, M.D.

Associate Professor of Orthopaedic Surgery, Rush Medical College; Attending Orthopaedic Surgeon, St. Luke's Hospital, Chicago, Ill.

DEFORMITIES and disabilities of the feet, due to infantile paralysis or other causes, have received a great deal of attention from the orthopaedic surgeons for many years. Certain fundamental principles have been developed which are well worth following. The essential aim of this kind of reconstruction surgery is the improvement of the function of the foot. The damage done by the attack of poliomyelitis, or the traumatism to nerves or muscles by war wound or civil injury, has produced a distorted or unstable mechanism upon which the individual must walk with a degree of difficulty corresponding to the degree of disability. In the early days of surgery, little attempt was made to change the shape of the deformed foot. The shoemaker did his best to supply a covering which fitted the foot, but his efforts ended there. The unfortunate patient walked upon the point of the heel, or the ends of the metatarsal bones, or the side of the cuboid bone, with no prospect or possibility of improvement. In later years, tenotomy and forcible correction offered much hope, but little fulfillment, except in the cases of congenital club foot. It soon became evident that simple correction, or even overcorrection, of paralytic talipes never produced a permanent cure of the deformity. Slowly, but surely, the distortions recurred, in spite of the most carefully designed braces and apparatus. Then came the brilliant tendon-transplantations, ingenious and fascinating. It is simple and easy to convert flexors into extensors; abductors in adductors, etc.; they will functionate, they will obey the mind's commands, but they will not prevent or cure deformity in the feet. The most successful results seen in a large number of carefully performed tendon transplantations recently reviewed by the writer were observed in cases where extensive cuneiform osteotomies had been done simultaneously for the relief of bony deformities. By reason of these osteotomies, some of the joints of the foot, usually the medio-tarsal, had been obliterated, and an ankylosis or arthrodesis had resulted. In practically all other instances,

FIG. I. F. M.

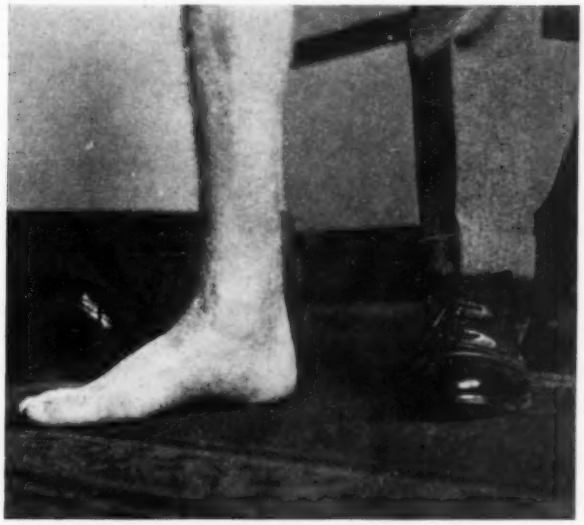

FIG. II. F.M.

FIG. III. F. M.

Paralytic equino-valgus. Triple arthrodesis. Peroneus longus transplanted into tibialis anticus. Operation Nov. 1, 1921. The last two pictures were taken March 13th, 1922.

although the tendon transfers were technically successful, deformity had recurred, sometimes in its original form, sometimes in a different form, but always deformity. The causes of this lack of practical success were, in general, due to three main factors. First, lack of power on account of (a) disparity in size between the transplanted muscle and the one which it was desired to replace; (b) adhesions limiting the range of contractility of the transplanted muscle (much less frequent under the later technique of Biesalski and Mayer); (c) mechanical difficulties resulting from change in direction or function, as in transferring a peroneus longus to act as a tibialis anticus, or making a flexor serve as an extensor; also, failure to suture the tendon under exactly the proper amount of tension. Second, the difficulty in securing an exact balance of power when more than one set of motors were paralyzed, as, for example, combined paralysis of tibialis anticus and posticus, or triceps surae and tibialis posticus, etc. When two groups are paralyzed, the problem of reconstruction is usually too complicated for simple tendon transplantation. Third, the fact that the foot is not a rigid lever, but is made up of many joints which are capable of independent motion, whose mobility cannot be controlled completely by the ordinary tendon transplantations. Under the severe strains of locomotion and weight-bearing, these imperfectly controlled joints become distorted, and deformities soon make their appearance. The subastragaloid and medio-tarsal joints are the most frequent offenders, followed by the tarso-metatarsal joints.

It is a common experience to find that a tendon transplantation which for many months seems to be a brilliant success gradually becomes less and less efficient, and at the end of two or three years is found to be wholly unsatisfactory from its inability to control the lateral deforming influences. The best results of tendon-transplantation seen by the writer have been where the extensor proprius hallucis was made to act as a tibialis anticus, and where the semitendinosus and the long head of the biceps femoris were transplanted forward into the patella. Although the upper extremity is not included in this paper, it should be mentioned that the results of transplantation in the arm and forearm are much more uniformly satisfactory than in the lower extremity.

One of the most disappointing operations has been the attempt to control varus deformity in the foot by the transplantation of the tibialis anticus as a whole, or in part, to the outer border of the foot. This operation at first seems to be successful, but is always followed by a return of the varus, because the medio-tarsal joint is not properly controlled by the muscle insertion, which has been made at a point distal

to this joint. This operation should be abandoned, in favor of a medio-tarsal arthrodesis.

Next in order came the useful and practical operation devised by Royal Whitman, astragalectomy and backward displacement of the foot. It was designed for the relief of calcaneus and calcaneo-valgus deformities, and has unqestionably been the most generally successful method in use at the present time in the treatment of this particular deformity. Many operators, however, have used it in cases of equino-varus, and the results have been almost uniformly unsatisfactory. The reason for this is not difficult to understand. The removal of the astragalus leaves a large gap or defect in the bony continuity of the inner border of the foot, and although the tibia partly fills this gap, it fails to prevent the recurrence of the varus deformity. In the opinion of the writer of this paper, therefore, astragalectomy should not be performed in any cases of varus deformity where it can be avoided. In a very few cases of great severity (usually neglected cases of considerable age), it may be impossible to obtain sufficient correction unless the astragalus be removed and in such cases the operation should be supplemented by the lateral arthrodesis to be later described.

Silk ligaments, and the implantation of tendons into the tibia and fibula to control varus and valgus deformity have not stood the test of time. They have an inherent mechanical defect, in that they act simply as guy ropes from the leg bones, and they do not prevent motion in the subastragaloid and medio-tarsal joints. They often act admirably to check plantar flexion in "drop-foot," but they do not control rotation and lateral deformity. Implantation or tenodesis of the tibialis anticus or the tendo Achillis by Gallie's method is often useful as an adjuvant to other operations.

Careful analysis of the cases studied in the series previously referred to has led to the conclusion that the chief cause of complaint and disability is the development of lateral deformity in the feet. Calcaneus deformity can be relieved by Whitman's operation. Drop-foot can be relieved by braces or by Gallie's tendon implantation. Lateral deformity, varus or valgus, cannot uniformly be relieved by either method. Some one has observed, and correctly observed, that a person with an artificial leg and foot walks much better than most persons with infantile paralysis. One of the chief reasons is that the ankle joint and foot in an artificial leg are capable of motion only in flexion and extension, the most important motions, and the only really necessary motions, in ordinary walking. There are no deformities in the artificial foot, no painful projections of bone, no calluses or bursae, no lateral instabilities.

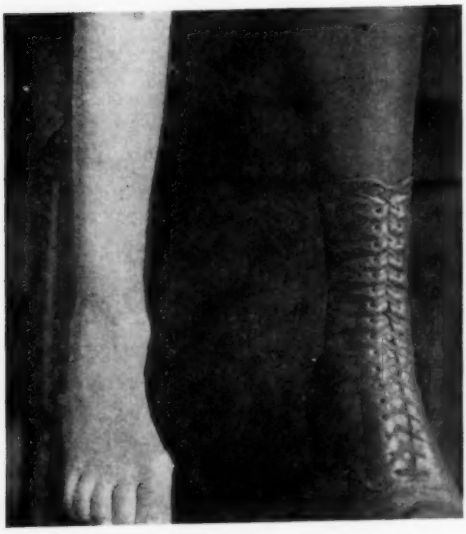

FIG. I. E. Y.

FIG. II. E. Y.
Silk ligament suspension, 1914.

FIG. III. E. Y.

FIG. IV. E. Y.

FIG. V. E. Y.

After triple arthrodesis, 1914.

Silk ligament suspension, March, 1914. In 1922 foot began to turn in to varus. Triple arthrodesis performed July 5, 1922. The last three pictures were taken six months after the arthrodesis.

FIG. I. S. O.

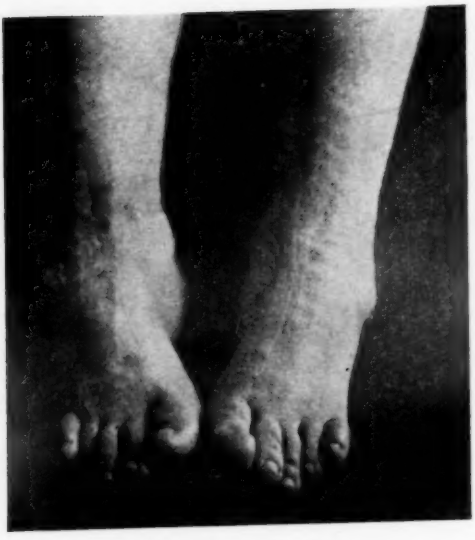

FIG. II. S. O.

FIG. III. S. O.

FIG. IV. S. O.

Paralytic equino varus.

Right foot—Steindler stripping of os calcis. Tendo Achillis lengthened. Hoke's remodelling of head of astragalus. Piece of cuboid inserted into astragalo-scaphoid joint. Ext. Prop. Hall. inserted into first metatarsal. Calcaneo-cuboid arthrodesis, also subastragaloid.

Left foot—No subastragaloid arthrodesis, otherwise same operation.

Last two pictures taken eight months after operation.

Why should we not, then, so stabilize the tarsus and metatarsus that these lateral deformities and disabilities cannot occur? The astragalus is held with sufficient firmness by the malleoli, in most cases, to prevent lateral motion of this bone. If, now, we fasten all of the other important bones of the foot to the astragalus, we ought to obtain a foot which is incapable of lateral deviation. Gwilym Davis was probably the first operator to see this proposition clearly, and he devised the horizonal section of the foot, cutting through the joint between the astragalus and calcaneus and then forward in a horizontal plane through the head of the astragalus and the upper part of the scaphoid. No bone or cartilage is removed, but the adjoining surfaces of the astragalus and calcaneus are thoroughly dug up and the chips allowed to remain. The soft tissues having been freely detached, and the chisel-gouge having been freely thrust through from one side of the tarsus to the other, a complete horizontal transverse section of the foot, just below the malleoli, has been made. The foot is then forcibly thrust backward about 2 cm., the two incisions sutured, and a plaster of Paris dressing applied with the foot in slight equinus and with no lateral deviation in either direction. This produces an ankylosis of the subastragaloid and the medio-tarsal joints, and very effectually checks all lateral distortion which might occur by reason of motion in these particular joints. Davis' operation has apparently been very infrequently used, to judge by the literature, and yet it was brilliantly conceived and is of great practical value. Like Whitman's operation of astragalectomy and backward displacement, it was designed for the deformity of calcaneocavus, but it prevents lateral deformity in a much more certain and satisfactory manner than does Whitman's operation. It also has the advantage of producing no shortening of the total length of the leg from knee to sole. It does not produce so much stability in cases where the astragalus fits loosely between the malleoli, but in such cases the external malleolus can be cut obliquely and bent into closer contact with the astragalus.

There are some cases, however, where well-marked lateral deformity exists beyond the medio-tarsal joint, usually a varus position, rarely a valgus. In such cases, besides fusing the medio-tarsal joint, it is desirable and practicable to cause a fusion of, first, and most important, the joint between the cuboid and the base of the fifth metatarsal bone, and, next, the joints between the scaphoid, the internal cuneiform, and the first metatarsal bones. This operation has been performed by the writer in a small series of cases, and with results which seem to be satisfactory. An interesting fact has been noted in one case, which may prove to be of considerable importance.

A boy of 7½ years was operated upon in 1920 for a rather severe varus with slight equinus. The cartilage was carefully cut away from the astragalo-scaphoid, the calcaneo-cuboid, and the cubo-fifth metatarsal joints, and the subastragaloid joint was curetted and gouged. The foot was kept in a plaster of Paris splint for three months. Examination in January, 1923, showed a stable, straight, and useful foot, with none of the former tendency to varus deformity. There was, however, no fusion whatever in the astragalo-scaphoid joint. This joint was as freely movable as before, except that its lateral excursions could not be carried out on account of a very complete fusion of the bones on the outer side of the foot. The result, then, is practically as satisfactory as if the astragalo-scaphoid joint were also ankylosed, and there is, in addition, slightly more flexibility of the foot. Whether or not this "lateral arthrodesis" will be sufficient to maintain a correct position of the foot in other cases, remains to be seen. The operation is much easier and more accurate than the astragalo-scaphoid arthrodesis, since the two joints are nearly plane surfaces and the cartilage can be cut off with a few strokes of the chisel. It can probably be performed with success in younger children than can the astragalo-scaphoid arthrodesis, because the layers of cartilage are thinner than in the head of the astragalus, at equal ages, and it is therefore easier to obtain approximation and union of the denuded surfaces. The combined operation should always be performed, however, except possibly in cases of severe varus deformity where it is not desirable to shorten the inner border of the foot.

The purpose of this paper is to advance the following proposition:

1. Lateral deformities of the feet, especially those due to paralysis, are the source of considerable disability.

2. They have not been so successfully provided for as have the deformities of calcaneo-cavus and talipes equinus.

3. They can be effectually treated by arthrodesis of the subastragaloid, the medio-tarsal, and the first and fifth tarso-metatarsal joints.

4. No radical operations should be performed until at least two years have elapsed since the acute attack, nor until careful trial has been made of non-operative treatment, such as muscle training and protection of weakened muscles by apparatus. These operations are much more successful in children over 12 years of age than in younger children.

Muscle training has its distinct limitations. It cannot restore life to dead nerve-cells, but it *can* help weak muscles to hypertrophy, and can train some individuals to use weakened muscles to better advantage. When muscle-training has reached its limit, and this limit falls short of the minimum power necessary for successful locomotion or the pre-

FIG. I. R. B.

FIG. II. R. B.

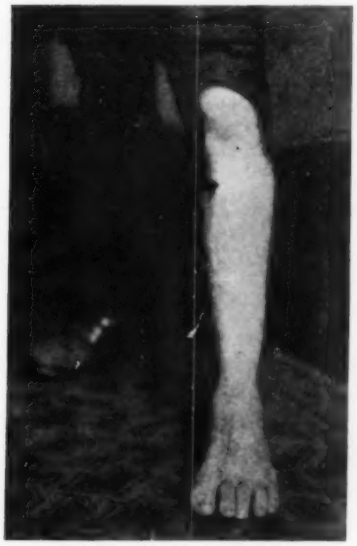

FIG. III. R. B.

FIG. IV. R. B.

FIG. V. R. B.

Hollow claw foot, with varus. Steindler stripping of os calcis. Wedge from dorsum of foot, including astragalo-scaphoid and calcaneo-cuboid joints. Sub-astragaloid joint curetted. Operation July 7th, 1921. Last three pictures taken Dec. 19, 1921.

vention of deformity, then the patient must choose between operation or a life time of brace-wearing. Even this statement must be qualified, for there are a few unfortunates in every large community who cannot be made to walk either by operation or by braces. Fortunately, these cases are very rare. Braces are unsightly, cumbersome, and annoying, and do not control lateral deformity.

Technique of triple and lateral arthrodesis: the "triple arthrodesis" is indicated where most of the weakness and deformity occur in the subastragaloid and medio-tarsal joints. Mid-tarsal valgus and varus, and the severe hollow claw foot are good examples. The operation is most easily and accurately performed by two incisions, one on the inner and one on the outer side of the foot. A Martin bandage (broad, thin, flat rubber, three inches wide and five or six feet long) is applied from the toes to the knee, the turns barely overlapping each other. It should be wound on snugly, and on reaching the top of the calf just below the knee-joint it should be secured by several turns. The end at the foot is then unwound as far as the knee, and tied or clamped to the upper end. This gives a bloodless field and greatly facilitates the difficult dissection. An incision is now made from just posterior to the inner malleolus, and immediately below it, through the skin only, and carried directly over the astragaloscaphoid articulation and to about the middle of the first metatarsal bone. Below the malleolus the tendon of the tibialis posticus is identified, its sheath is opened, and the tendon is retracted upward. This exposes the joint at the sustentaculum tali, between the astragalus and calcaneum, and further retraction backward will show the posterior part of the substragaloid joint. A narrow chisel, or preferably a Davis flat gouge, can be used to cut loose the articular cartilage, and a very small, strong curette is used to complete the denudation, going as far toward the outer side of the joint as possible.

Next, the astragalo-scaphoid joint is exposed, and opened by cutting the capsule. The attachments of the capsule and ligaments can be peeled away with a chisel, and the cartilage is then cut loose and curetted out. This joint is extensive, and the denudation must be very thorough. In small children, 6 or 7 years of age, the cartilage on the head of the astragalus is nearly one-quarter of an inch thick, and by the time the bleeding bone of the ossification center is reached, there is practically no possibility of bony contact between it and the denuded concave surface of the scaphoid. This is one of the chief reasons for not operating on young children, and is the most frequent cause of non-fusion in this joint. In children of 10 years or more, the cartilage is thinner and the results are proportionately better with each additional year up to 12 or 13. It

FIG. I. R. M.

FIG. II. R. M.

Severe hollow claw feet. Cuneiform osteotomy with sub-astragaloid arthrodesis. July 11, 1922. Also, Steindler stripping of os calcis. These pictures taken seven months after operation.

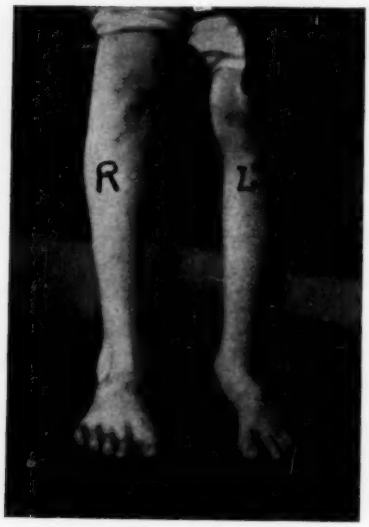

FIG. I. R. H.

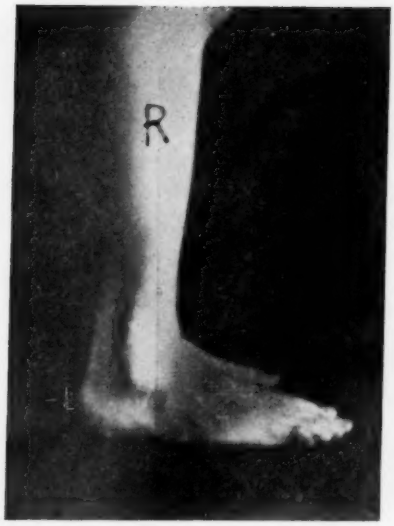

FIG. II. R. H.

FIG. III. R. H.

Operated at 7½ years of age, Feb. 20th, 1920. Triple arthrodesis *right* foot. Astragalo-scaphoid joint did not ankylose, but remains perfectly free. Foot is held perfectly by the calcaneo cuboid fusion. These pictures taken 2¾ years after operation. Left foot has never been operated upon.

is especially necessary to denude the lateral (outer) aspect of this joint with great care, so that, when the calcaneo-cuboid joint is correspondingly denuded, there will be a complete transverse section through the entire foot, the medio-tarsal joint thus being entirely denuded. If any marked degree of varus or valgus be present, a wedge shaped piece can be removed from the outer or inner section of the medio-tarsal joint sufficient to correct the deformity. If the condition be one of pes cavus or hollow claw foot or calcaneus, the base of the wedge should be upward.

The joints between the scaphoid, internal cuneiform, and base of the first metatarsal can be similarly denuded if deformity beyond the medio-tarsal joint be present or be likely to occur. This part of the operation may not often be required, but should be used especially in severe cases of hollow claw foot.

An incision, similar to the first one, is now made on the outer (lateral) border of the foot, beginning just posterior to and below the external malleolus and extending distally to or beyond the base of the fifth metatarsal bone. The sheath of the peroneus tendons is opened and the tendons displaced and retracted upward, exposing the lateral portion of the subastragaloid joint. This is rather short, and slants upward and backward. It can usually be completely denuded with chisel and small curette, without cutting the external lateral ligamentous structures. The subastragaloid joint, with its two or three subdivisions, is by far the most difficult of all of the joints of the foot to expose and clean out in a proper surgical manner. After this has been done, the calcaneo-cuboid joint is denuded, and made continuous with the astragalo-scaphoid joints, so that the foot is completely mobilized and freed up through the whole extent of the medio-tarsal region. Next, the cubo-metatarsal articulation is attacked and the cartilage cleaned out. The foot as a whole is then viewed as to the complete correction of any pre-existing deformity, and whatever remodelling may be necessary is then done. If, now, there seems to be too great laxness or instability, chromic catgut may be used to bind the bones together, by passing it through drill-holes. This precaution has been very seldom used by the writer, most often, perhaps, in cases of hollow claw foot where a very large wedge has been removed. The wounds are then sutured with interrupted or occasionally-interrupted stitches, after the tourniquet has been removed. The bleeding, very fresh at first, usually becomes inconsiderable after a few minutes, but a few large skin veins may require tying. The work has been largely in the joints and under the periosteum, and the main vessels are not likely to be injured. After suturing, it is wise to insert a few strands of silkworm gut in spaces between sutures, in both outer and inner

FIG. I. E. H.

FIG. II. E. H.

Arthrodesis all tarsal bones on inner side of foot. Ext. Prop. Hallucis transplanted into tibialis anticus. Tendo Achillis lengthened. Operation, March 2, 1921. These pictures taken Nov. 2, 1921.

wounds. These drains prevent accumulation of blood in the tissues, and greatly reduce the post-operative pain and swelling. Sterile vaseline is smeared over the wounds, and dressings, folded long and narrow, are placed over the line of sutures. Sterile sheet wadding is wound thickly over the foot and leg, bandaged snugly, and covered with a light layer of plaster of Paris, reinforced on back of leg and bottom of foot with a 2-inch moulded plaster "rope" or splint. If only one foot has been operated upon, it is well to carry the plaster far up on the thigh, with the knee straight, and to suspend the whole leg by straps or frame, as advised by Whitman after astragalectomy. The whole plaster splint should be cut on each side from top to toes, so as to make anterior and posterior halves, and this cut should include the cloth or gauze bandage down to the sheet wadding. If all of these rules be followed, constriction will be avoided and the pain after the operation will be very slight. The cuts in the cast must be made low enough so that when the anterior or dorsal half is lifted off, the two incisions, low down on the two sides of the foot, will be exposed for inspection and dressing, and removal of drains and sutures. The silkworm drains are left in place for 48 hours. It might seem to those who have had no experience with this form of operation that it was unnecessarily extensive, or severe, or dangerous, but this is not the case. The transverse section through the medio-tarsal joint, cuneiform or otherwise, has been done by the writer in a large number of cases, and with the addition of the subastragaloid and other joints in more than fifty. In some of these cases, where the details of drainage and proper splitting of the cast were not carried out, there was severe post-operative pain for several days. In most other instances, there was less pain than after such simpler operations as forcible correction with tenotomies.

The results are extremely satisfactory, so far as observed, and the procedure is recommended as safe and logical. It is believed that it furnishes better stabilization and more central correction than osteotomies in the continuity of the bones. When a partially paralyzed foot has been stabilized in this way, tendon transplantations can be done to provide flexion and extension, with the certainty that disabling lateral deformity will not occur. It is in such cases that transplantation finds its true field of usefulness.

In conclusion, attention may again be directed to the essential instability of the imperfectly controlled medio-tarsal and sub-astragaloid joints as one of the most frequent causes of deformity and disability in paralysis of the leg.

HAMSTRING TRANSPLANTATION FOR QUADRICEPS PARALYSIS.*

BY PAUL C. COLONNA, M.D., NEW YORK, N. Y.

For the purpose of ascertaining the end-results of transplanting one or more hamstrings for loss of function in the quadriceps, due to infantile paralysis, the writer has analyzed the records of 101 cases at the Hospital for Ruptured and Crippled in the five year interval between January 1, 1915 and January 1, 1920, and has personally examined 24 of this group. In this series transplantation of the biceps was done in 78 instances, and the inner hamstrings were transplanted 23 times.

The operator in the majority of the reported series and in 75 of the total number was Dr. Royal Whitman, to whom I am indebted for permission to study these cases. The remaining 26 of the total number were operated on by 13 different surgeons, practically the same technique being employed in all the cases.

The ideal indication for transplanting one or more of the hamstrings is paralysis of the quadriceps extensor alone. Often, however, there is found an associated deformity, such as fixed flexion at the knee, knock-knee, etc., or deformity due to paralysis of one or more muscles of the thigh or leg, which should be corrected if possible before attempting hamstring transplantation.

It has been noted that in walking very little power is needed to extend the leg, as extension is assisted by gravity, and it is only with weight-bearing that the transplanted muscle is called upon to perform its most important duty—that of holding the leg extended. A slight recurvatum at the knee, therefore, may sometimes be desirable, provided the remaining muscles about the posterior portion of the knee-joint are well-developed; otherwise an extreme recurvatum will develop, necessitating the permanent use of a brace. The power of kicking forward, that most of these patients develop following operation, is of value not only in walking, but serves as a mental stimulus for increased effort on the part of patients who never walked without the aid of braces or crutches. Some stabilizing operation on the foot is desirable in many of these cases, and astragalectomy with backward displacement of the foot was satisfactorily employed in 20 of those studied.

*Read at a Clinical Conference of the Hospital for Ruptured and Crippled, January 24, 1923.

Where many individual factors have to be considered for each case the true criterion for the success or failure of an operation such as hamstring transplantation must be considered only in conjunction with other operations necessary for the individual case, and while for convenience the appended chart gives the degrees of extension possible, against the action of gravity, the "Results" are based on the combined necessary treatments received—of which hamstring transplantation was the important but not sole factor. The small size of the transplanted hamstrings in comparison with the powerful quadriceps, as well as the obliquity of the transplanted muscle, makes it evident that full extension is necessarily a rare result, and one that it would be unfair to expect. The fact that the apparently paralyzed quadriceps has a varying return of power following transplantation was well demonstrated in several cases of this series and this doubtless explains many results of "full extension" which have been reported.

The technique employed in this series was as follows: An incision was made on the outer or inner side of the thigh, extending from about the middle of the thigh to a little below the knee. When the biceps was used the tendon of insertion, together with a section of bone or cartilage, was separated from the head of the fibula, care being taken to avoid injuring the peroneal nerve, and dissected back, with the short attachment of the biceps to the femur at a point where the muscle may pull in a direct line from the tuberosity of the ischium to the patella. An incision was then made over the patella exposing the tendon of the quadriceps, the transplanted tendon was drawn through a spacious subcutaneous tunnel, and the bony fragment on the end of the tendon firmly secured under the periosteal covering of the patella by means of karangoo sutures. In a few cases the operator pierced the quadriceps tendon and then inserted the transplanted tendon into the patella, but this apparently was an unessential detail which did not affect the end-result.

The wounds were closed with plain cat-gut, dressings were applied, and the limb was supported by plaster of Paris extending from the toes to the groin, the knee usually being in full extension. The plaster was worn from six to eight weeks, then bivalved, and the strength of the transplanted muscle developed by exercises in bed, retaining the posterior shell as a support. After three or four weeks the patient was encouraged to bear weight on the limb, wearing a supporting brace for several months thereafter.

No.	Name Hist. No. Operator	Age at Polio. Age at Op. Present Age	Pre-operative Examination
1.	L. S. 11903 B.	1 8 16	Discarded left long brace at three years of age. Paralysis of left quadriceps with foot in equinus. Good power in hamstrings.
2.	Y. O. 12679 W.	2 9 17	Wears double long braces with pelvic band. Falls frequently. Right quadriceps weak but active. Left quadriceps paralyzed but good power in hamstrings. Both feet in attitude of calcaneovalgus.
3.	A. B. 12589 W.	½ 13 21	Wears right long brace and short left leg brace. Right lower extremity totally paralyzed. Left quadriceps partially paralyzed, can extend leg about 140°. Good hamstring power on left.
4.	A. C. 12339 W.	2 8 15	Child very fat and walks awkwardly. Wears long brace with pelvic band on right. Paralysis of right ilio-psoas and quadriceps with good power in hamstrings. Right foot in valgus.
5.	H. C. 12326 W.	½ 12 19	Only able to walk with aid of crutches. Wore right long brace up to time of astragalectomy, one year ago. Paralysis of right quadriceps with flexion contraction of knee. Hamstrings in good condition. Right foot in attitude of calcaneovalgus.
6.	S. F. 12470 W.	½ 7 16	Wears right long brace with pelvic band. Paralysis of the right quadriceps and all the muscles below the knee except the toe flexors.
7.	C. A. 12036 W.	2½ 10 18	Patient unable to stand without support. Wears double long spring brace with pelvic band. Contractions at right hip and knee, with paralysis of entire left lower extremity. Right foot in attitude of equinus and "dangle foot" on left. Able to extend right leg to about 115°.
8.	L. O. 12823 W.	½ 9 16	Wears right long brace with pelvic band and short left leg brace. All muscles of right lower extremity paralyzed with exception of hamstrings, of which the internal group are the stronger. Both feet in attitude of calcaneovalgus.
9.	C. D. 12971 W.	2 8 15	Walks very badly, wearing right long brace. Paralysis of the right quadriceps with right foot in calcaneovalgus. Good power in hamstrings—inner group being stronger.
10.	O. P. 12932 G.	½ 7 14	Wears left long brace with quadriceps paralysis and no power below knee on left. Hamstrings weak but active.

Muscle Transplanted	Supplementary Operations	Post-operative Examination	Results
Left biceps	Lengthening T. A.	Patient walks well, wearing no brace. There is slight recurvatum left knee, with outward displacement of patella on extension. Able to extend left leg to 120°.	Good
Left biceps	Bil. astrag.	Patient walks well, wearing no braces. No recurvatum, but moderate degree knock-knee present. Able to extend left leg to 120°.	Excellent
Left biceps	Bil. astrag.	Wears right long brace. No recurvatum. Apparently some return of power in left quadriceps. Able to extend left leg to 170°.	Fair
Right biceps	Ant. displac. of rt. tibialis posticus	Patient overweight. Wears no brace but states he falls occasionally. No recurvatum. Parents state child "greatly improved" since operation. Extends right leg to 150°.	Good
Right semi-memb.	Right astrag.	Walks with aid of crutch, wearing no brace. No recurvatum. Falls occasionally. No extension right leg against gravity but can fully extend when lying on side.	Poor
Right biceps	Right astrag.	Patient walks well with no recurvatum. Able to discard brace one year after transplantation. Definite return of power in quadriceps. Extends right leg to 140°.	Excellent
Right biceps	Left astrag. Tenotomy hip flexors & T. A. Stretchings	Wears left long brace. No recurvatum or outward displacement of patella. Extends right leg to 145°.	Excellent
Right semi-memb.	Bil. astrag.	Wears right long brace. No extension of right leg against gravity. There is a moderate recurvatum of the right knee.	Poor
Right inner group	Right astrag.	Wore right long brace for several years after operation but at present walks without brace. No recurvatum. Able to extend right leg to 140°.	Excellent
Left biceps	Left astrag.	Walks well, wearing no brace. No recurvatum. Able to extend left leg to 100°.	Excellent

No.	Name Hist. No. Operator	Age at Polio. Age at Op. Present Age	Pre-operative Examination
11.	H. B. 12751 S.	½ 10 17	Wears left long brace with pelvic band. Slight contraction of left knee. Left quadriceps paralysis and no power below the knee.
12	R. B.	2 6 13	Wears short left leg brace with paralysis of left quadriceps and no power below the knee. Inner group of hamstrings are stronger.
13.	J. C. 12892 T.	2 5 12	Unable to walk unassisted. Wears right long brace with pelvic band. Slight contraction of right knee. Paralysis of quadriceps and no power below the knee on the right. Good hamstring power though inner group is stronger.
14.	J. G. 13553 R.	5 13 19	Wears long brace with pelvic band on right and short left leg brace on left. Right quadriceps is weak but active. All muscles below knee on left completely paralyzed.
15.	S. B. 12586 W.	2 21 29	Walks with difficulty, wearing left long brace. Paralysis of the left quadriceps and no power below the knee. Inner group of hamstrings are the stronger.
16.	L. S. 12511 W.	1 9 17	Wears left long brace with pelvic band. Patient is very fat and unable to walk without assistance. Paralysis of left hip and thigh muscles except hamstrings. Left foot in valgus. Right knee is hyperextended and there is no power below the knee.
17.	E. F. 13301 W.	2 9 16	Wears left long brace. Paralysis of quadriceps and all muscles below knee on the left. Good hamstring power.
18.	H. L. 13197	3 8 15	Wears right long brace with pelvic band. Moderate contraction of right hip and knee. Paralysis of right quadriceps and no power below the knee.
19.	I. K. 13693 Z.	2 16 22	Wears double long braces with pelvic band. Hip muscles on the right are weak but active. Paralysis of the right quadriceps and foot in equino-varus. Paralysis of the left ilio-psoas and quadriceps. Foot in equino-varus. Good power in both right and left hamstrings.
20.	F. S. 14436 W.	½ 5 11	Wears left long brace. There is contraction with slight subluxation of the left knee. Paralysis of the left quadriceps and no power below the knee.
21.	G. V. 12543 W.	2½ 11 19	Walks with aid of crutches, dragging left leg and wearing short leg brace on right. Paralysis of left quadriceps and biceps. No power below knee on left.

Muscle Transplanted	Supplementary Operations	Post-operative Examination	Results
Left biceps	Left astrag.	Wears left long brace. Patient states she is "greatly improved." Able to extend left leg to 130°.	Good
Left inner group	Left astrag.	Wears no brace. There is apparently some power in left quadriceps. Able to extend left leg to 155°.	Excellent
Right inner group	Right astrag.	Walks well, wearing no brace. No recurvatum. Able to extend right leg to 160°.	Excellent
Right biceps	Right astrag.	Wears long brace on right but is able to walk without braces. No recurvatum. Able to extend right leg to 120°.	Good
Left inner group	Left astrag.	Wears left long brace but walks well without brace. Able to extend left leg to 150°.	Excellent
Left biceps	No record	Patient is much over-weight. Walks fairly well, wearing left long brace. Slight recurvatum of the left knee. Able to extend left leg to 140°.	Good
Left inner group	Left astrag.	Wears no brace. No recurvatum. Patient states she is able to dance. Able to extend left leg to 100°.	Excellent
Right biceps	Tenotomy of right hip flexors Right astrag.	Wears right long brace but can walk without brace. Right patella is displaced outwards during extension. No recurvatum. Able to extend right leg to 105°.	Fair
Right biceps	Right astrag. Left wedge osteotomy	Wears double long braces but is able to walk without braces. Patient states she is "improved." Able to extend right leg to 140°.	Fair
Left biceps	Left astrag.	Discarded left long brace two years after operation. Falls occasionally. No recurvatum. No extension of left leg against gravity.	Fair
Left inner group	Left astrag..	Walks without crutches, using left long brace and short leg brace on right. Able to extend left leg to 120°.	Good

No.	Name Hist. No. Operator	Age at Polio. Age at Op. Present Age	Pre-operative Examination
22.	J. E. 14869 W.	2 11 16	Wears right long brace with pelvic band. Flexion deformity of right hip and knee. Paralysis of right quadriceps and no power below the knee. Right hamstrings weak but active.
23.	H. W. 14131 W.	2 10 15	Wears double long braces with pelvic band, but unable to walk without the aid of crutches. Paralysis of the right and left quadriceps. Flexion deformity of both hips. Bilateral recurvatum. No power below the knee on either side.
24.			

Careful study of the 24 cases which returned for examination and the records of 77 others seem to warrant the following conclusions:

1. Satisfactory functional results with hamstring transplantation for quadriceps paralysis are the rule rather than the exception.

2. Any accompanying deformity should, if possible, be corrected before transplantation.

3. If sufficient strength exists in the biceps, transplantation of this muscle usually gives better results than those obtained using the inner group of hamstrings.

4. Negative results are apt to follow if the extensors of the hip are also paralyzed.

Muscle Transplanted	Supplementary Operations	Post-operative Examination	Results
Right inner group	Right astrag.	Wears right long brace. Mother states child is "greatly improved by operation." No recurvatum. Able to extend right leg to 110°.	Fair
Right and left biceps	Bil. astrag.	Patient able to attend school and walks without aid of crutches, wearing double long braces. Parents much pleased with improvement. No extension of either leg against gravity.	Good

5. From a physiological standpoint it is interesting to consider how the afferent stimuli, accustomed as they are in initiating the motor response to "flex" can be re-educated and taught to respond to what would appear to be contradictory afferent impulses.

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EXPERIMENTAL INCISION ON THE CADAVER FOR DRAINAGE OF THE ANKLE JOINT.

BY SOLOMON D. DAVID, M.D.

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A SEARCH through available surgical literature on arthrotomy of the ankle joint for the purpose of drainage revealed several methods with radically variable value inherent in each. Usually these incisions are described in the following order: anterior external, posterior external, anterior internal, posterior internal, and the anterior median incisions. Neither specific preference nor differential discrimination are expressed as to any of these incisions relative to the pathological indication, and the operator is left to select any incision of this collection for ankle joint drainage.

In order to ascertain an operative approach to the ankle joint that is reasonably safe, efficacious, and simple for drainage, the writer has carried out a series of experiments on the cadaver with this purpose as his object. These experiments were carried out in the Anatomical Laboratories of the Harvard Medical School, and thanks are due to this institution for making the work feasible.

Since accurate knowledge of anatomy is indispensable for those who essay to do surgery on joints, a word concerning the anatomy of the ankle may not be out of place. The ankle mechanism is a hinge joint, one surface of which is formed by the lower end of the tibia with its internal malleolus, the lower end of the fibula (the external malleolus) and the transverse ligament binding together the tibia and fibula. These structures by their shape form a mortise to receive the dorsal and lateral articular surface of the astragalus as a tenon. Powerful ligaments on the lateral aspects support this complex hinge mortise and tenon.

The deltoid, or the internal lateral ligament, extends from the internal malleolus to the rough edge of the astragalus. From the lateral expansion fasciculi extend to the sustentaculum tali at its mid portion, calcaneal tubercle behind, and to the dorsal astragalo-scaphoid ligament in front.

The external lateral ligament is composed of three portions. The anterior fasciculus extends from the external malleolus to the rough surface of the astragalus immediately above the sinus pedis; the middle

runs to the calcaneal tubercle, and the posterior fasciculus passes almost horizontally to the external tubercle of the talus.

The anterior ligament is membraniform, supported by the tendons passing over it and by a sheet of fat. Its weakness is most manifest in the antero-external aspect.

The posterior ligament is composed of weak, thin, shredlike incomplete membrane extending from the tibia to the astragalus behind. It is strengthened and supported in the postero-medial interval by the tendons of the structures, and in the postero-lateral interval by a thick cushion of adipose tissue. The posterior tibial nerve, artery, and vein lie medial to the flexor longus hallucis in the medial interval.

Several experiments on ankle joints of cadavers were made, each of the five routes of approach to the ankle joints was tested, and the joints were then dissected for further study. The object was, as stated above, to discover an incision safe, easy, and efficient for the evacuation of a purulent effusion of the joint. Glycerine, because of its close resemblance in consistency to that of pus and because of being less diffusible in non-formalin injected material, was used for injection, either through a hole made in the lower end of the tibia or through the anterior ligament. Methylene blue was employed as a coloring substance.

I. ANTERIOR EXTERNAL INCISION.

Through this route the largest amount of the injected fluid was evacuated with the foot in marked plantar flexion. Some of the fluid was found retained in the posterior compartment, created by an imaginary transverse line drawn through the center of the malleoli. With the foot dorsi-flexed, most of the fluid settled in the posterior compartment. This route appears to be good for counter drainage and antero-posterior irrigation.

II. ANTERIOR INTERNAL INCISION.

This is similar to the preceding. Accurate knowledge of the ankle joint is a prerequisite, as the incision might easily enter the sheath of the anterior tibial. There is, however, less room in this region than in the external aspect, and both of these incisions tend to bring the contents of the joint in contact with vital structures.

III. ANTERIOR MEDIAN INCISION.

This incision runs over the neck of the astragalus and the tendons of the extensors of the toes and foot. Upon entering the joint, the foot being plantar flexed, the fluid was found collected in the lateral unsupported portions of the anterior ligament. This is easily explained by the

inherent weakness of these portions. Furthermore, this route seems to be dangerous, deficient, and to possess no particular merit.

IV. POSTERIOR INTERNAL INCISION.

This route brings many important structures into view and invites possible accident. The flexor longus hallucis, hugging the internal portion of the posterior ligament, lies close to the tendo Achillis. Immediately medial to it, the following structures come in order: posterior tibial nerve, vein, artery, vein, flexor digitorum longus, and the posterior tibial muscle.

V. POSTERIOR EXTERNAL INCISION.

This route proved in each experiment to be competent for drainage and safe. It affords ample and easy access. For this incision the foot should be dorsi-flexed, which represents the best functional position for fixation. Every drop of the fluid may be evacuated, provided the foot is placed in the dorsi-flexed position, which position tends to obliterate the anterior compartment and correspondingly to increase the posterior one. With the foot plantar flexed, the anterior compartment retained some of the injected matter. This incision is made in the posterior external aspect of the ankle joint 1½ cm. medial to the tendo Achillis, beginning 5 cm. above the external malleolus and extending down to the os calcis, following the anterior border for 1½ cm. The external saphenous nerve and vein are encountered and retracted posteriorly. A thick pad of fat is seen hugging the posterior ligament. This may be pressed down against the entrance to the subastragaloid joint for protection. The ankle joint is entered above the shining cordlike posterior fasciculus of the external lateral ligament. Incidentally, it may be remarked that this incision affords an excellent approach for drainage of the subastragaloid joint as well.

CONCLUSIONS.

For the purpose of simplicity, the ankle joint may be divided into two compartments by an imaginary line passing transversely through the center of the malleoli. The posterior compartment is formed by the posterior surface of the trochlea, the anterior being formed by the relaxation of the anterior ligament over the neck of the astragalus.

In thirteen experiments on thirteen ankle joints of the cadaver, it seemed to be proved that the posterior external approach was a reliable approach and a safe one, as far as encountering important structures is concerned. The joint cavity is easily accessible by this route, and with the foot dorsi-flexed to a right angle, evacuation of the fluid was complete.

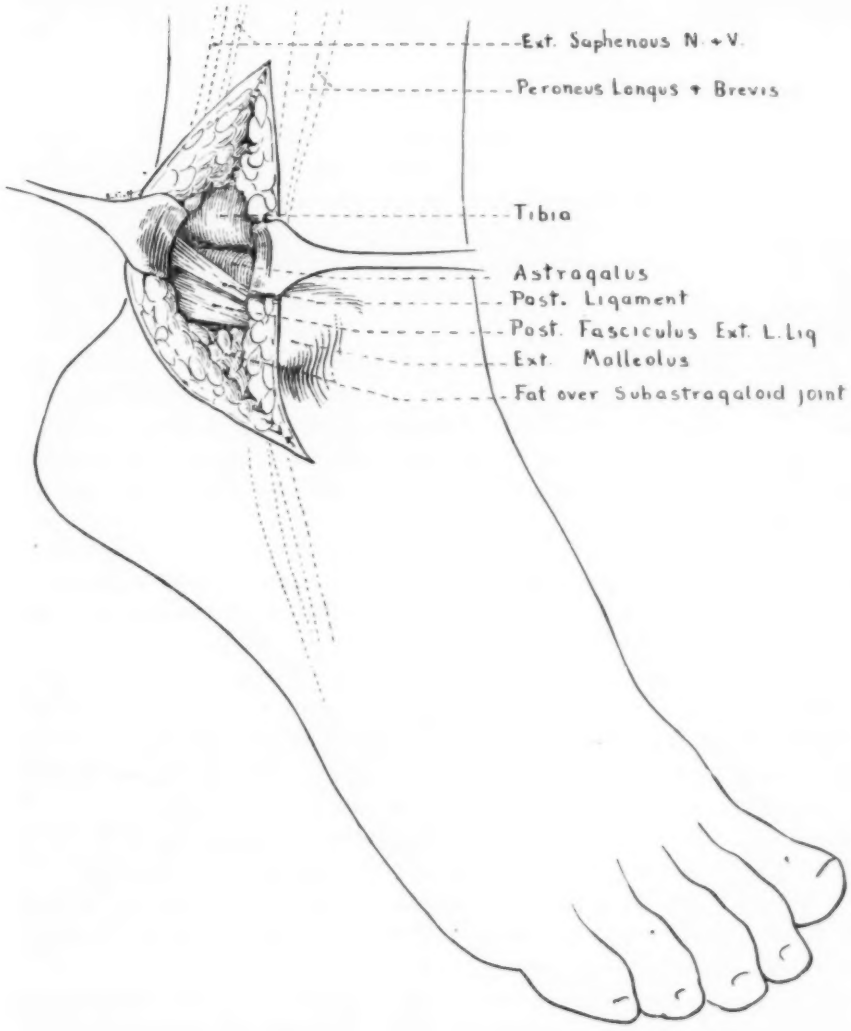

FIG. 1.—The posterior external incision for arthrotomy of the right ankle joint as advocated above. The portion of the posterior ligament is shown by the artist to be more pronounced than it actually is. The shining posterior fasciculus of the external lateral ligament lies immediately below the entrance into the ankle joint and above the calcaneo-astragaloid articulation.

A SURGICAL APPROACH FOR STEP OPERATIONS ON THE FEMUR.

BY ARTHUR KRIDA, M.D., NEW YORK.

An approach to opposite sides of the femur, such as is desirable in step operations for lengthening (or shortening) the femur, must take into account primarily the distribution of the nerve supply to the components of the quadriceps extensor muscle, and minimize as much as possible the amount of direct trauma to the muscle tissue and to the bone. The approach described below conserves muscle tissue and secures an adequate exposure, and by permitting the use of a motor saw, minimizes the trauma to the bone. The procedure was developed on the cadaver.

A curved skin incision is made on the front of the thigh. Beginning in the upper third of the thigh in the midline, it curves externally, then downward, then inward, to a point one inch above and internal to the patella. The skin flap is reflected.

The first incision in the deep fascia is made in the line between the vastus externus and the rectus femoris. Beginning from below, these muscles are separated to a point rather above the middle of the thigh. This exposes the lateral surface of the crureus. The blood vessels and nerve to the vastus externus enter the vastus in the upper angle of separation. The lateral surface of the femur is exposed by an incision through the crureus and periosteum. A saw cut of the required length is made with the motor saw. The saw cut should be sufficiently long to allow of at least a two-inch approximation of the two halves of the step.

The second incision in the deep fascia is made in the line between the vastus internus and the rectus femoris. These muscles are then separated, beginning from below and extending upward as high as the separation on the outer side. This exposes the medial surface of the crureus. The nerve to the crureus enters near the upper angle of the wound and passes downward and outward on the anterior surface of the muscle. The medial surface of the femur is exposed by an incision through the crureus and periosteum, and a saw cut of equal length to the first one and opposite to the same is made. The step is completed by passing a Gigli saw sub-periosteally and sawing from behind at the upper end, and from before at the lower end.

DORSAL WEDGE OPERATION FOR METATARSAL EQUINUS.

RICHMOND STEPHENS, M.D., NEW YORK, N. Y.

Most orthopaedic surgeons agree that the Whitman operation of astragalectomy with backward displacement of the foot is the most satisfactory procedure to stabilize a dangle foot due to paralysis following anterior poliomyelitis. A great many of these operations have been done at St. Charles Hospital for Crippled Children at Port Jefferson, Long Island, and the patients have in most instances remained in the hospital under constant observation for many months or years. It has been noted that in a small proportion of cases, about six per cent, there has developed equinus of the fore-part of the foot of a degree which has been serious enough to require further operative treatment.

If the Whitman operation has been properly performed, the posterior portion of the foot is in correct relation to the leg and the portion distal to the tarso-metatarsal junction may drop, thus producing a deformity which might be called cavus, but which we have designated as metatarsal equinus, as this term seems to be more descriptive. In cases of complete dangle foot this condition is presumably due to gravity, but in many of the cases grouped with dangle foot there is some power in the short plantar flexors, and therefore there may be some contraction of these muscles causing the deformity. Occasionally at the time of the astragalectomy it has been noted that metatarsal equinus may be expected to result, but in most cases it has not been expected or seen until several months later.

The resulting metatarsal equinus may be slight in degree and require no treatment, but in twenty cases it has been severe enough to interfere with the use of a brace or made it difficult to get the foot in a shoe. The deformity is sometimes fixed, but more often flail in character. In the cases operated upon there has been so much of a drop of the forefoot that the dorsal surface was on the same plane as the anterior surface of the leg.

It was decided that a real and permanent correction could be obtained only by a bony fixation, and in January, 1921, the first case was operated upon. Various minor changes have been made since to facilitate the procedure and various incisions have been used. The present technique

PLATE I.

Case—Right foot after astragalectomy, but before wedge operation, showing extreme metatarsal equinus.
Lower picture shows foot after dorsal wedge operation

PLATE II.

Plaster models of a foot showing inner and outer sides before and after dorsal wedge operation.

of the operation is as follows: A two inch median longitudinal incision through the skin and subcutaneous tissue is made over the dorsum of the foot, with the center over the tarso-metatarsal junction. The deep soft structures are separated by blunt dissection and retracted laterally, exposing the row of tarso-metatarsal joints. A wide osteotome is then inserted, and a wedge of bone with base up and apex down is removed, this wedge including the joints and a portion of the proximal heads of the metatarsals and distal portion of the tarsus. The deformity is then corrected and the gap thereby closed. Two kangaroo tendon sutures through the dorsal periosteum are used to hold the position and keep the space closed. The deep soft structures are then allowed to fall back in place and the skin closed with plain catgut sutures. A sterile dressing is applied and the foot placed in plaster-of-paris to hold the corrected position. After four weeks the plaster is removed and replaced by another for four weeks more and in which walking is permitted.

It is readily seen that the operation is very easy and in a general way is similar to any form of wedge. It is somewhat simplified by the use of a tourniquet at the lower third of the thigh. If there is any varus or valgus present with the equinus, the wedge may be removed with its base somewhat to the outer or inner side of the foot as the case may be, as well as dorsal.

In our series of twenty cases the first operation was performed on January 20, 1921 and the last one on December 5, 1922. The majority of the cases have been watched for some time and the results thus far seem to be permanent and very satisfactory. Eighteen out of twenty are classed as excellent; one of these, however, was re-operated upon as the wedge removed at the first operation was not enough to give full correction. One case is good, but with slight metatarsal equino-varus, and one other case will require operation for varus.

The table below gives the important data on these cases and the illustrations show a typical case before and after the wedge operation and also plaster models of a case before and after.

Number of Operations 20 (on 18 patients).
Foot involved—10 Right. 10 Left.
Sex of patient—7 Female. 13 Male.
Date of paralysis—12 cases in 1916. 8 before 1916.
Date of astragalectomy—Earliest March 27, 1915. Latest Sept. 27, 1921.
Date of Wedge operation—Earliest Jan. 20, 1921. Latest Dec. 5, 1922.
Age at onset—Oldest 7 yrs. Youngest 1 yr. Average 2 yrs., 6 mos.

Age at Astragalectomy—Oldest 13 yrs. Youngest 4 yrs. Average 6 yrs., 4 mos.

Age at Wedge—Oldest 15 yrs. Youngest 6 yrs. Average 9 yrs., 3 mos.

Age at present—Oldest 16 yrs. Youngest 7 yrs. Average 10 yrs., 6 mos.

Interval between paralysis and astragalectomy—Longest 11 yrs. Shortest, 2 yrs. Average 4 yrs.

Interval between astragalectomy and wedge—Longest 6 yrs., 2 mos. Shortest 6 mos. Average 2 yrs., 9 mos.

Interval between wedge and last examination—Longest 2 yrs., 1 mo. Shortest 2 mos. Average 1 yr.

Results—Foot in excellent position and requires no further treatment—18
Foot in fair position but has slight equino-varus—1
Foot in poor position and requires further treatment for varus—1

Walking without apparatus—8.

Walking with braces—11 (because of paralysis higher up).

One case died of pneumonia 5 months after wedge operation but foot was in excellent condition.

CONCLUSIONS.

1. Some dangle feet develop metatarsal equinus after astragalectomy and backward displacement which is severe enough to require further operative treatment.

2. A simple dorsal wedge operation has been done for this condition.

3. The results have been very good to date and 90 per cent of the cases are classed as cured.

A POST-OPERATIVE RETENTIVE APPARATUS FOR TORTICOLLIS CASES

ROY M. HOOVER, M.D.

New York Orthopædic Dispensary and Hospital, New York.

More or less difficulty has always been experienced in the post-operative retention of torticollis cases, and in the New York Orthopædic Dispensary and Hospital all the usual methods have been tried, with frequently unsatisfactory results. These methods included plaster of Paris, braces, strapping with adhesive plaster, and oblique bed traction.

In an attempt to overcome the faults of all these methods, the following apparatus was devised, and has been in use for almost two years with uniformly excellent results. It overcomes all the disadvantages of the other methods.

It is really a modification of the old adhesive strapping method, with a very essential difference. Buckles are interposed between the cranial and thoracic portions of the adhesive straps.

The exact arrangement of the straps and their number vary with the individual case. Usually the arrangement is similar to the illustrations. Three strips of adhesive with straps attached are applied to the head, and either three with buckles attached, or two, one of which carries two buckles, are applied to the trunk extending well down to the pelvis.

These straps are so placed that the head is held in marked over-correction, the chin being rotated toward the affected side, and the head being tilted far over toward the other shoulder.

In cases in which it is undesirable to apply adhesive to the hair, a well-padded plaster cap in which the cranial straps are incorporated may be successfully used. This is seldom necessary, however, as the transverse straps need only to be attached at their ends, and the circular band is at or below the hair margin. In this way but little of the hair is covered by the adhesive.

All the essentials of a retentive apparatus in post-operative care of torticollis are fulfilled by this arrangement. It holds the head in the desired position and is adjustable. It can be released at any time and as often as desired for massage and exercise. It is simple and so comfortable that patients are willing to be up as soon as it is post-operatively desirable.

THE TREATMENT OF CHRONIC BONE ABSCESSES BY SIMPLE EVACUATION THROUGH A SMALL DRILL HOLE. ITS APPLICATION IN NON-STERILE ABSCESSES.

BY WALTER M. BRICKNER, B.S., M.D., F.A.C.S., NEW YORK.

From the Surgical Service of Mount Sinai Hospital

In two earlier publications* I discussed the pathology of chronic bone abscesses, cortical and medullary, and their diagnostic features, and described my method of treating such abscesses, small or large, by mere evacuation through a drill hole.

"The technique of my procedure, as developed, is as follows: Under nitrous oxide narcosis, an incision about 2 inches long is made through the skin and (except, for example, over the inner surface of the tibia) the underlying muscle is split, or retracted, to expose the periosteum. Through this and into the bone, at a point determined by roentgenogram or by the level of maximum tenderness, a drill about one-fourth inch in diameter is driven deep enough to permit the escape of pus. If, perchance, the situation of a small abscess has not been estimated sufficiently accurately for it to be thus tapped by the first opening, other drill holes can be made with little damage to the bone, or the surgeon may defer the completion of the operation to determine roentgenographically the relative levels of the abscess and his first drill hole. With the escape of pus the drill is removed and *nothing else is introduced into the bone*—no probe, curette, or gauze packing! A culture is made from the pus to determine what, if any, living organism it contains. A smear is also stained and examined at once. The purpose of the latter is that if, instead of few or no bacteria, many are found, the surgeon may, if he thinks it desirable, enlarge the bone opening or otherwise modify the procedure. A small drain of folded rubber dam is laid in the soft parts

*Brickner, Walter M.: Chronic medullary abscess of the long bones. Its clinical and roentgenographic features: its treatment by simple trephining. Annals of Surgery, April, 1917 (*55*, 483).

Chronic bone abscess. Its treatment by simple evacuation through a drill hole. Surgery, Gynecology and Obstetrics, July, 1922 (*35*, 84).

down to, but not into, the opening in the bone, and the wound is otherwise closed by sutures. A simple gauze dressing completes the operation.

"The drain is to provide for any further escape of pus from the bone, and to act as a safety-valve in case of possible suppuration in the bone cavity or the soft parts caused by dormant organisms awakened to activity. It is removed, usually without replacement, in three or four days, i.e., as soon as discharge has practically ceased. The small opening in the soft parts is then allowed to close and, ordinarily, healing of the entire wound is complete in ten days or less, but few of which, usually, are spent in bed. Contrast this with the prolonged disability and invalidism, not to speak of the scarring and deformity, of wide-open osteotomy and slow "healing from the bottom," with its inherent risks of sequestrum formation and secondary operations!"

The method is based on the conception—the correctness of which has been verified by further observations—that chronic bone abscesses tend

Fig. 1. Abscess in the lower end of the tibia twenty years after acute osteomyelitis. Note that there is very little sclerosis of surrounding bone.

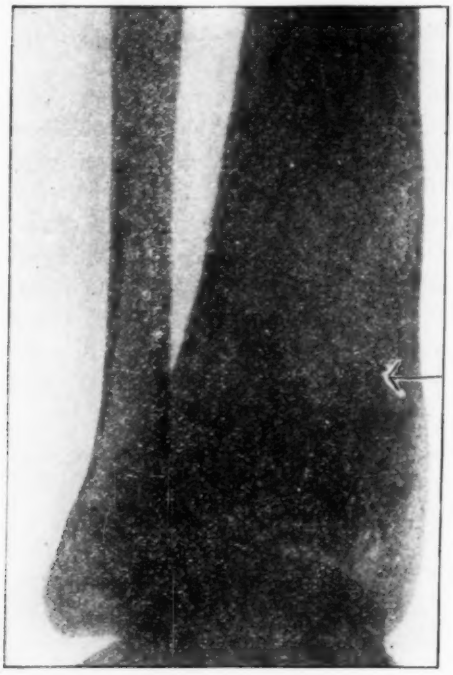

Fig. 2. The same case as Fig. 1, eighteen months after evacuation of the abscess through a small drill hole. Note that the cavity is not entirely obliterated.

to become sterile and afebrile. In my last article, however, I hazarded the suggestion that this procedure might also prove successful in some, at least, of those cases of chronic bone abscess in which clinical signs—daily mild elevation of temperature, slowly increasing pain and tenderness—indicate that the pus is not sterile but that the virulence of the organisms is slight. And I reported therein the case of an abscess in the lower end of a tibia (figures 1 and 2) that had twenty years previously been the seat of an extensive acute osteomyelitis, which abscess was satisfactorily treated by evacuation through a ⅛-inch drill hole four weeks after its first manifestation of slowly increasing symptoms—pain, tenderness, local heat, and evening elevations of temperature (100.5°-101°). The presence of the staphylococcus (aureus) was determined by both smears and cultures from the pus.

The purpose of the present brief communication is to demonstrate, by further illustrative cases, that complete sterility of the pus is not essential to the success of this method of treating chronic bone abscess.

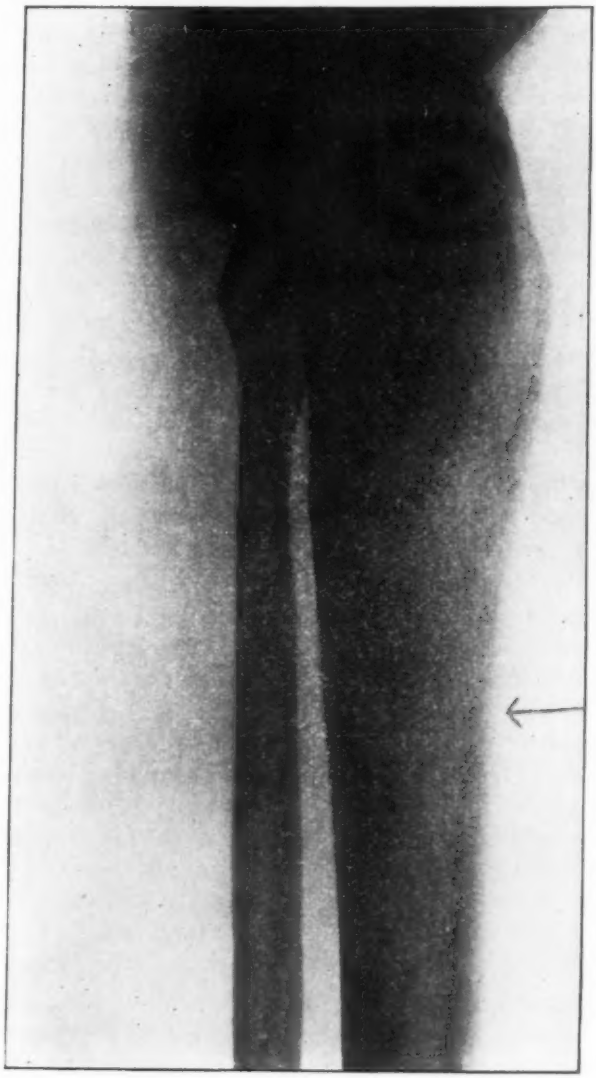

Fig. 3. Benjamin G. Bilocular abscess in the right tibia, metastatic from chronic suppuration in the left femur, tibia and knee joint. Note that there is almost no condensation of the surrounding bone.

Benjamin G., aged 40, had been under treatment on the services of Drs. Elsberg and Moschcowitz at Mount Sinai Hospital, New York (214074), for over one year for osteomyelitis of the left femur and tibia and pyarthrosis of the left knee. He had undergone numerous operations, the last on November 24, 1922. On December 7, 1922, when his left leg was approaching surgical cure, he complained of pain in the upper inner aspect of the *right* leg. Five days later there was noted a circumscribed, red, tender swelling at about the junction of the upper and middle thirds of the right shin, suggesting a localized bone infection. A roentgenogram on December 14th (figure 3) showed a bilocular abscess in the cortex of the tibia, about 2 cm. x 1.5 cm. in diameters.

On December 19, 1922, under nitrous oxide narcosis, a small incision was made through the skin over the swelling, exposing the slightly thickened periosteum. Through this and the bone cortex was plunged a motor-driven drill of about 3-16-inch diameter, allowing the escape of a few drops of thick pus. With a stout probe the bony septum separating the two portions of the abscess was then broken through and the deeper collection of pus escaped. No drain was inserted, but a wet dressing was applied over the small wound.

Smears of the pus, examined while the patient was still on the table, showed a few Gram-positive cocci; culture developed a pure growth of staphylococcus aureus. At the time of the operation, but also for many weeks before that, the evening temperature had usually been 99.8° or 100°, which might equally have been caused by the process in the left or that in the right leg. After the drilling, however, the highest temperature was 99.4°. The pain was promptly relieved by the evacuation of the pus; the swelling rapidly subsided; and the small wound healed in a few days. When the patient was discharged from the hospital, two months later, with the left leg also almost healed, he had had no recurrence of any sign or symptom in the right leg.

If we assume that the abscess in the right tibia had its inception at the time of the first complaint of pain (12 days before the drilling) then we may regard this, not as a chronic but as a *subacute* abscess, in which, however, the organisms were, for that patient, of a low grade of virulence. The roentgenogram (figure 3) in this case, like those of the case above referred to, shows practically no reaction (condensation) in the bone surrounding the abscess—which also favors a presumption that the process was a recent one. It is, however, quite possible that the staphylococcus had invaded the right tibia some time before and had developed renewed activity at the time that the pain and swelling appeared.

Bertha L., aged 13, was admitted on December 8, 1922 to the service of Dr. Elsberg, Mount Sinai Hospital (225444) from the out-patient department (Dr. Chargin), where she had been under treatment since 1917 for congenital syphilis. In 1917 also she had been operated upon at the hospital for acute osteomyelitis of the left tibia.

Seven weeks before admission pain had appeared abruptly in the right arm, and it continued, worse at night. Swelling appeared about three weeks later and increased slowly. Fever had been noted a few days before admission to the hospital. Although the Wassermann blood reaction had become and remained negative, active specific treatment (by mercury and salvarsan) was continued, without influencing the process in the arm.

While under observation at the hospital there were noted: the somewhat tender, fusiform, rather hard swelling in the lower third of the right arm that is shown in the photograph (figure 4); irregular pupils; opacity of the left lens; shortening (2½″) and extensive scarring of

Fig. 4. Bertha L. Medullary abscess of the right humerus probably metastatic from an (antecedent) osteomyelitis of the left tibia.

Fig. 5. Roentgenogram from the same case as Fig. 4. Accumulation of pus in the medullary cavity, with moderate surrounding ostitis and periostitis. The light circular area is the trephine opening made a few days before the x-ray exposure.

the left leg; corresponding scoliosis; negative blood and spinal fluid Wassermann reactions; daily temperature range between 99° and 100°; and the roentgenographic appearance of the right humerus seen in figure 5.

Essentially this roentgenogram is that of a circumscribed osteoperiostitis and, taken with a careful consideration of the history, signs and symptoms as here recorded, it should have led us to a more positive diagnosis. The history of lues, however, confused our judgment and we were in doubt whether we had to deal with a syphilitic, a pyogenic (abscess), or possibly even a neoplastic involvement of the humerus.

Dr. Elsberg accepted my suggestion to explore the bone with a small cranial trephine, both for gross inspection and to secure a specimen for histologic study. This I accordingly did under ether on December 22nd, through an incision on the outer aspect of the arm safely anterior to the musculospiral nerve. The periosteum was found much thickened, but soft, the bone cortex (at the level of trephinage) also much thickened, but otherwise healthy. When the button of periosteum and bone was removed there escaped from the medullary cavity above, an ounce or more of thick pus. Smears made at once showed no organisms. A rubber dam drain was inserted in the wound to, but not into, the bone, and the skin was otherwise reunited with sutures.

After operation the temperature rose for a day to 103° then dropped to 100° and soon to 99°, where it remained. On the fourth day there was no discharge and the drain was then removed without replacement. A week later the wound was entirely closed, the pain and tenderness had ceased and the swelling was much less. The child was kept in the hospital to secure a raised shoe for the left foot, and then discharged (January 8, 1923). Cultures of the pus had developed the staphylococcus aureus. Histologic examination of the bone button showed chronic inflammation of the periosteum, sclerosis of the bone, no spirochaetae.

In this case, too, one may speculate whether the abscess in the humerus had its inception with the pain that began seven weeks before admission to the hospital or whether the infection had been long dormant there—perhaps since 1917.

An abscess in the bone substance (corticalis) usually shows clearly in the roentgenogram, but, as I have previously pointed out, an abscess within the medullary canal usually cannot be recognized as such, roent-

genographically. The x-ray appearance then is that of the associated osteoperiostitis, by which the abscess can be diagnosed only in connection with the clinical signs—pain and tenderness.

While in all of the still rather few cases of bone abscess in which I have employed simple drainage through a small drill hole, immediate relief and early and thus-far permanent healing were secured, I am prepared to believe that this will not always happen. It is quite conceivable that, as the result of introducing a secondary infection or of the awakening into activity of dormant organisms, suppuration may continue and require further operation. Even accepting such a possibility, however, I believe that there is much to be gained and little to be lost by a trial of the simple minor operation which I again present for surgical consideration.

It will be seen that the procedure is curative not merely in chronic, sterile bone abscesses but also in those chronic (and subacute?) bone abscesses in which living organisms are still present but not virulent. The method is not recommended for acute pyogenic bone infection with high fever.

A NEW PORTABLE PLASTER OF PARIS SPICA FRAME.

BY LOUIS A. O. GODDU, M.D., BOSTON, MASS.

THE following is a description of the writer's handy spica apparatus.

It consists, as the drawing shows, of a back piece that is 9″ by 9″, made of ⅛″ gas pipe. There are four legs which are screwed into each corner, made up of steel ½″ in diameter, and 7″ long. The sacral piece is made in parts; the base has an upright, which is screwed on the brace; the sacral parts consist of a large and small size; the upper pin that binds the sacral piece.

This spica can be carried in a small canvas bag, which is 10½″ by 10½″, and ½″ thick, making a portable apparatus that can be carried in an ordinary bag.

It has been exhibited before the Boston Orthopaedic Club, and has been used at the Massachusetts General Hospital. The writer has used it for several years, and feels justified in recommending it as a very handy apparatus for putting on plaster-of-paris spicas. A plaster can be applied easily with a patient in bed, by putting some boards on the bed and setting up the frame, as shown in the cut.

CASE OF OSTEOMYELITIS OF THE ULNA, WITH COMPLETE REGENERATION, IN AN OLD PATIENT.

BY LOUIS A. O. GODDU, M.D., BOSTON, MASS.

THE patient was injured Dec. 2, 1921, cutting the back of his right hand, severing some of the tendons. He was attended by a local physician, who sewed up the tendons and skin, leaving a wick in the incision. Three weeks later, patient was going downstairs, slipped and fell, striking his elbow, after which the elbow became swollen, hot, and red. He was again attended by his local physician. This indefinite history is about all I was able to get. The obvious point seemed to be that the man injured his hand, evidently had some sepsis, which apparently cleared up, with infection in the elbow three weeks later.

April 5, 1922, patient was examined at the writer's office. He was a man of 66 years, old for his age, appeared dejected and in exceedingly poor condition. He handled his right forearm very carefully, supporting it with his left hand; all motions were rather painful. Patient's physical examination showed myocarditis, marked arteriosclerosis, and a chronic nephritis; in fact, he presented a poor general condition. Examination of his right arm showed that the middle fingers of the right hand were limited in motion, wrist limited, elbow swollen, tender, hot, with some fluctuation, which extended along the forearm on the dorsal aspect. Elbow could not flex beyond right angle, and extension was limited to within 45° of straight line. X-Rays were advised. These, as can be seen by plate No. 1, showed a marked osteomyelitis of the right ulna, with a slight involvement of the head of the radius. Patient definitely a poor risk.

The problem presented was whether or not amputation or a radical excision of the ulna, which was involved, would offer this patient his best chance. As it was perfectly obvious that the patient could not stand long anaesthesia, and that whatever surgical procedures were resorted to would have to be done rather quickly, it was decided that the patient would perhaps have his best chance with a quick operation, under gas oxygen, for the removal of his entire ulna. This operation was advised.

Operation: April 10, 1922. Patient brought to the operating room, and the writer and his assistant prepared everything for immediate

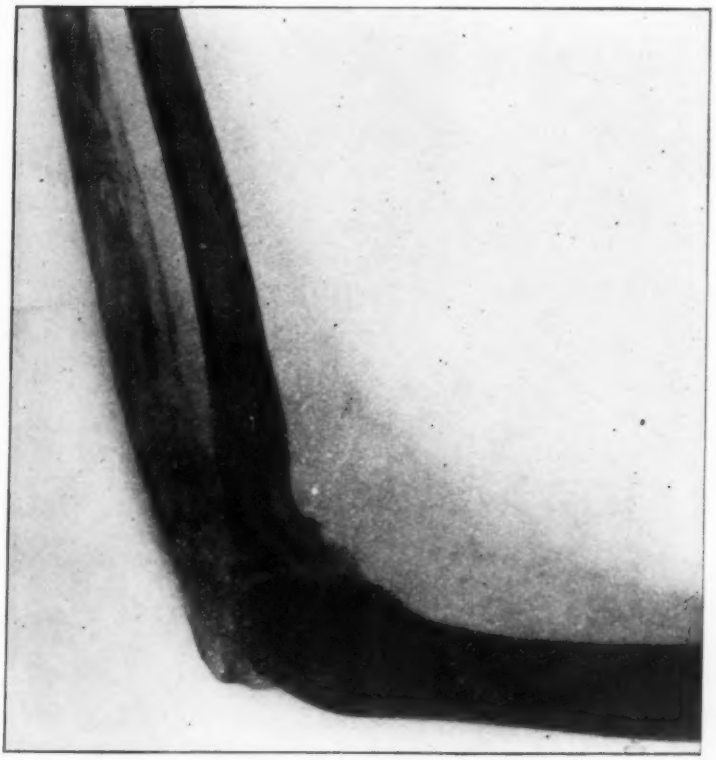

PLATE No. 1. Shows marked osteomyelitis of ulna, with slight involvement of radius.

operative procedures, when patient first showed signs of succumbing to anaesthesia. An incision beginning at the elbow and carried down and directly over the wrist was made; blunt dissector was inserted in the fascia and followed down to the ulna, upward and downward, exposing the entire ulna, which was easily and quickly removed sub-periosteally. Hot saline and handkerchiefs controlled the hemorrhage; wound left wide open, packed with sponges moistened with Dakin's solution; patient back to bed in twenty minutes, and recovery was good.

The subsequent course of the wound was excellent, the filling in of granulations was gradual and progressive. Carrel and Dakin dressings done every day. By June 3rd the wound was practically healed, except a region about the elbow which seemed to be difficult to handle, because of the depth of the wound and rapid progress of the new bone formation. The infection apparently seemed to be resistant and to have involved the new bone in this area.

PLATE No. 2. June 2, shows a marked arterio-sclerosis of the vessel, also shows the vessel and new bone formation coming down to portion of ulna left in situ.

On June 12th X-Rays showed a rather interesting situation, in that in the time between April 10th and June 12th an entire new ulna had regenerated, and if observed carefully, it can be seen that the patient developed what apparently is a good olecranon. It might be noticed that because of the loss of the support of the ulna the radius had become dislocated forward. One might argue that this situation could have been prevented by a Thomas splint, with the arm in extension, but it is to be noted that the writer's object was to clear up the infection primarily, because of the drain on the man's system, and the pain and infection, and second to get, if possible, a functioning hand irrespective of a serviceable elbow, which the writer feels he could not have done had he tied up the hand with any form of apparatus to give extension.

It is also to be noted that the writer considered it most important that this man be gotten out of bed as soon as possible, as we know this type of patient very willingly lies in bed and is rather loath to get up,

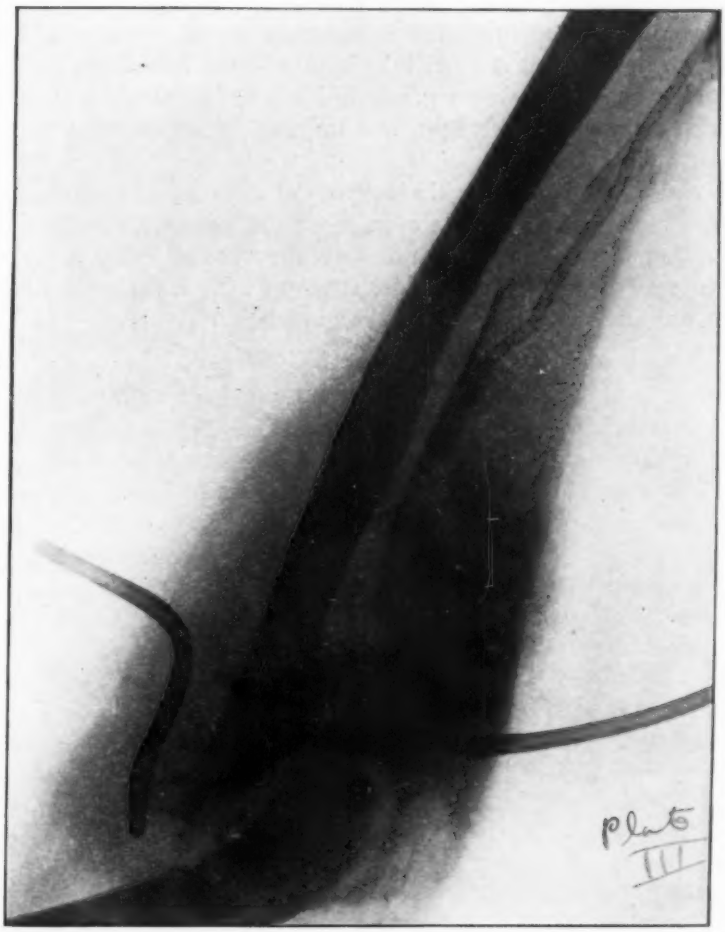

PLATE No. 3. Shows marked regeneration of the whole ulna, the proximal end of which shows some rarifaction and infection, as described in the article.

and at this age and with this amount of disability he was typical of this class of patient. A further consideration is that this man in his debilitated condition would have been an easy prey to hyperstatic pneumonia, and only by constant urging and persisting was the writer able to keep him up and about. The writer did not feel that further operative procedures were indicated as this man was all done as far as being any good as a workman was concerned when he arrived at the writer's office. The object of the entire procedure was to make him more comfortable, which object was apparently accomplished.

The writer still feels that he may be criticised for not amputating, but it would seem to him that amputation would have been a great shock; also this patient did not take kindly to the loss of his right forearm, and probably he was a great deal better off, alive, with a slight discharging sinus, which might heal up, and which, if it did not, was no real trouble to him.

This case is published for the purpose of showing how quickly sometimes the bone will regenerate even in an old person. Furthermore, it seems rather interesting because of several problems which it presented. A brace was given to hold the forearm up at a right angle, and the patient was advised to use the hand as much as possible.

A STUDY OF AUTOPSY SPECIMENS OF FUSED SPINES AND OF CASES SUBJECTED TO SECONDARY OPERATION.*

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THE following material from the New York Orthopaedic Hospital and Dispensary is presented as evidence of what occurs in spines operated upon for fusion by the method of Hibbs. It includes a study of ten autopsy specimens from about 600 cases of Pott's disease operated upon between 1912 and 1922. The age of the patients at operation was 18 months to 36 years, and the specimens were obtained at varying periods of from five weeks to three years after operation. In addition to this, a study was made of ten patients in whom a secondary operation afforded an opportunity of examining an area of spine which was fused at a previous operation. They represent all of the cases subjected to secondary operation in a series of 162 consecutive operations for tuberculosis of the spine, and of 59 consecutive operations for scoliosis. The reasons for re-operation were extension of the disease beyond the limits of the previously fused area, renewed activity of the disease, or suspicion that a point of pseudo-arthrosis or failure of fusion existed. The age at first operation in this second series varied from two to twenty-three years, and the period between the first and second operation from one year and one month to five years and seven months.

In nine of the autopsy specimens, the area operated upon shows a continuous column of bone including spinous processes, laminae, and in most cases, lateral articulations. In one case there is an irregular break across the bony column not more than one millimeter in thickness which was occupied in the recent state by fibrous tissue. This represents either a fracture subsequent to fusion, or more probably, a point where there was failure of fusion. It was found in nine of the re-operated cases that fusion was complete. In one, No. 16, a scoliosis case, there was failure of fusion at the apex of the curve.

The percentage of success in the operation cannot be computed from these cases because they represent a certain few in which a return of symptoms, an extension of disease, or in the scoliosis cases, an increase

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in the deformity seemed to indicate either an exploration of the operative field or an extension of the fused area. No attempt is made here to present facts which may be used in forming a judgment as to the effect of spine fusion upon the progress of Pott's disease or scoliosis. This may be found in other reports. The purpose is simply to present certain definite observations which may be of use in determining whether or not it is possible to obtain fusion of the spine by such an operation. While the number of autopsies may seem large, it is to be remembered that they are from a series of several hundred cases.

In view of the fact that doubt has been expressed as to the possibility of obtaining fusion of the spine in young children, examination of the specimen No. 1 is of interest. This is a section of spinal column removed at autopsy from a child 18 months old, who died from pneumonia on April 14, 1913, three months after a spine fusion operation performed for Pott's disease. The spinous processes, laminae, and articulations of the first to the sixth dorsal vertebra are fused in a column of bone in which the laminae are all fused together and in which only two adjacent spinous processes have failed to cement firmly. The result is a firm fusion of all six vertebrae operated upon.

The second specimen, that from No. 2, shows a very firm fusion of the twelfth dorsal to the fifth lumbar vertebra inclusive. This patient was operated upon for Pott's disease at the age of 2 years, and died of bronchopneumonia one year and eight months after operation.

The specimen from No. 3 presents a solid plaque of bone extending from the first lumbar to the fifth lumbar vertebra and comprising the spinous processes, laminae, and lateral articulations. This patient was operated upon for tuberculosis of the spine when 4 years of age and died five weeks later from tuberculous meningitis. It is a striking example of the rapidity with which takes place in a child, the consolidation and reconstruction of the elements placed at the disposal of nature by the operation.

No. 4 is that of a boy who was operated upon at 4 years of age for Pott's disease. Spine fusion was performed from the eleventh dorsal to the fourth lumbar vertebra. The patient died two and one-half months after operation. The specimen shows that fusion has taken place between all of the vertebrae and that the remodelling of the bone has proceeded at a remarkable rate. A small knob here and there is all that remains to identify the original spinous processes and bridges of bone between the laminae, the remainder of these structures having been fused into the general column.

One of the second series of cases was first operated upon at the age of 2 years, and four cases at the age of 3 years. These fields of operation were reëxamined at periods of from one year and eight months to four years later. In each case an uninterrupted column of bone was found.

The rapidity of the coalescence of the bony fragments has been mentioned in No. 3. This is the shortest time after operation, five weeks, at which any operated area has been examined. In light of what is known about the process of repair of comminuted fractures elsewhere, however, it is not surprising that fusion should take place in that time. The operation merely creates a condition in which numerous fragments of healthy bone, denuded of soft parts, are placed in contact with each other in an envelope of periosteum.

Although it is not safe to draw general conclusions from a small number of cases, it would seem from a comparison of cases, 1, 3, 4, 9 and 10, that reconstruction of the fragments into a solid column takes place more quickly in children than in adults. In specimen 3, which is from a child 4 years old five weeks after operation, approximately the same stage has been reached as in specimen 9, taken from a man 26 years old four months after operation. The consolidation is much firmer and the reconstruction of the bone fragments much farther advanced in the former than the portion of specimen 10, operated upon two months before death. No. 10 was a man 36 years old. In specimen 1, from an infant 18 months old, three months after operation, the process has gone at least as far as that in the first adult case at the end of two months. A much smoother column with more new bone formation is to be seen in specimen 4, taken from a 4-year-old child, two and one-half months after operation, than in either of the adult cases.

By examining the museum specimens and records of operation at various intervals of from five weeks to five years after the original operation, an interesting picture is had of the various phases in the remodelling of the fragments into a solid smooth column. In the earliest case, the spinous processes and bridges between the laminae are still to be distinguished, but their sharp edges have become lost and the various elements are already fusing into a solid plaque exactly as if they were made of metal and exposed to a high temperature. As the interval after operation increases, the identity of the individual fragments becomes less and less distinct, until finally it is lost in a homogeneous column of bone with a smooth surface. This is thicker in the center where it is formed by the spinous processes. In one specimen this central portion was found to be two centimeters in thickness.

In the earliest specimens the bone is pitted and perforated by numerous minute foraminae and the cortex is thin, but with the increase in the period elapsed after operation, the surface of the bone becomes smoother and harder.

In Case 17, failure of fusion was found at the point where it was suspected from clinical and x-ray examination. Occasionally the x-ray will demonstrate a pseudo-arthrosis, but as a rule it is not to be relied upon. It is sometimes difficult by clinical examination to determine whether or not there is failure of fusion at a certain point. The complete subsidence of symptoms following operation in the tuberculous cases is so constant and striking that any return of pain, muscle spasm and protective attitude, especially if accompanied by an increase in deformity, is considered, *per se*, to be evidence either of failure of fusion or of extension of the disease and therefore an indication for a second operation. The proportionate number of such cases is small.

A majority of the lumbar vertebrae were included in the area of fusion in six of the autopsy cases Nos. 2, 3, 4, 6, 7 and 10, and in two of the re-operated cases, Nos. 13 and 16. These represent patients operated upon at ages ranging from 2 to 36 years. The examinations, either at a second operation or at autopsy, were made at intervals of from five weeks to three years after operation. In all of the postmortem specimens, the lumbar vertebrae were firmly fused together by bone. In one of the re-operated cases there was failure of fusion between the twelfth dorsal and first lumbar and between the first and second lumbar vertebrae. Fusion was solid between the second and third lumbar. In the other re-operated cases all the four lumbar vertebrae which had been operated upon were strongly united by bone. This would seem to indicate that no more difficulty is to be expected in obtaining fusion in the lumbar region than in any other parts of the spine.

CONCLUSIONS.

1. Fusion of the spine may be accomplished by the Hibbs operation in practically all cases. (In a series of 221 operated cases, including both those of scoliosis and tuberculosis, failure of fusion occurred in only one case.)
2. The cause of failure to obtain fusion in the few instances in which it occurs is either inaccurate operative technic in securing bone contact, or infection.
3. There is no difficulty in obtaining fusion in young children.

4. The process of bone repair resulting in fusion proceeds much more rapidly in children than in adults, and therefore children are the most favorable subjects in whom to obtain spine fusion.

5. It is practically impossible to determine by x-ray examination whether or not fusion has occurred as a result of operation in a given area.

6. It is not more difficult to effect fusion in the lumbar region than in other parts of the spine.

AUTOPSY SPECIMENS.

No. 1, J. M., 18 months. Pott's disease. Duration unknown. Slight kyphos from third to sixth dorsal. Operation, January 14, 1913. Spine fusion. Spinous processes of first to seventh dorsal exposed. While the proportion of cartilage on the tips was greater than in older children,

FIG. 1. (Specimen 1.) Fusion of first to sixth dorsal vertebrae in eighteen months old child.

the spinous processes were surprisingly large, being one and three-eighths to one and one-half inches long. Periosteum stripped from spine easily. The first six dorsal spines were fractured in the usual way and laminal chips were loosened and turned down. Wound healed by primary union. April 14, 1913, the patient died of pneumonia, three months after operation. Section of spine operated on was removed at autopsy.

*Gross Pathological Description: The specimen consisted of 14 vertebrae measuring 15 cm. in length. The alignment of the spinal column is destroyed by a dorsal angulation situated six vertebrae from the upper end of the specimen. At the point of angulation the greater part of two vertebrae and the intervertebral disc are gone. The bone bounding the deficiency is roughened and granular where it enters into the boundary of the cavity. The spinal cord is well preserved. In the region of the kyphos, the posterior arches of six vertebrae are fused together. There is firm bone uniting the spinous processes of the first three vertebrae and the last two in this series. (Fusion has not yet occurred between the spinous processes of the third and fourth, but the laminae of all six are united.)

Microscopic Examination: The interspinous ligament extends inward from the tips of the spinous processes about halfway to the root. The site of the inner half of the ligament is bone. New trabeculae of bone extend across from one spinous process to the other, forming a dense mass. The interspinous ligament extending between the tips of the spinous processes is intact. (This was one of the early cases in which the dissection was not performed as thoroughly as it now is.). The roots of the spinous processes facing the cord show bony irregularity along their whole extent. Section from focus of degeneration shows tuberculosis.

No. 2, H. C., 2 years old. Pott's disease. Duration unknown. Marked rigidity of spine. Long rounded kyphos in dorsolumbar region. X-ray shows partial destruction of bodies of second and third lumbar. Operation August 4, 1916. Incision over dorsolumbar region exposing spinous processes of twelfth dorsal to fifth lumbar inclusive. Periosteum dissected away exposing lateral articulations and laminae. Usual laminal bridges and contact between spinous processes made. Discharged from ward December 6, 1916. Admitted to Country Branch, March 23, 1917. December 21, 1917, taken from hospital by parents. April 19,1918, readmitted to hospital. Mass in right iliac fossa. Hyperextension markedly limited in right hip, less marked in left. Patellar reflexes not

*Dr. William C. Clarke of the College of Physicians and Surgeons examined and described the specimen.

exaggerated. Kyphos rounded, reaching from tenth dorsal to fifth lumbar with greatest convexity at second lumbar. Fusion seems solid but kyphos has markedly increased. Spine is rigid and any manipulation causes spasm. Posture and gait protective. Profuse nasal discharge. Culture shows streptococci. Developed pustular skin eruption. Streptococci cultured from pus. May 16, 1918, patient died, one year and nine months after operation. Autopsy showed bronchopneumonia.

Specimen is a segment of spine 13 x 4 x 4 cm. including eighth dorsal to fifth lumbar. The first, second and third lumbar bodies have been largely destroyed, producing a posterior angular deformity in this region. The destruction has been more extensive on the right than on the left side, resulting in a cavity between the bodies on the right. The posterior arches of the eighth to the eleventh dorsal inclusive are not changed, but the spinous processes, laminae and articular processes of the twelfth

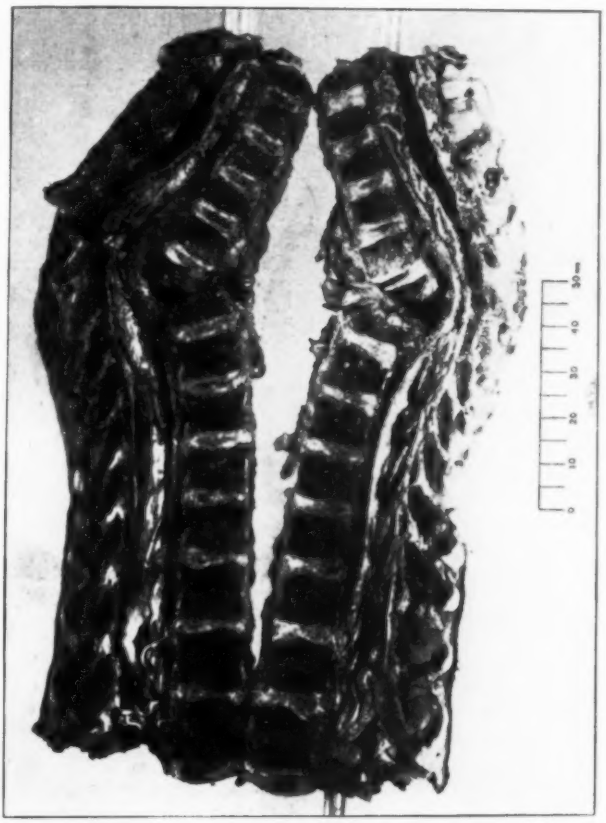

FIG. 2. (Specimen 1.) Vertical section showing area of disease.

dorsal and all the lumbar vertebrae are joined together in a continuous column of bone. At the upper end of this column is a small foramen, but this does not destroy the continuity or appreciably impair the strength of the fused area. The identity of the various elements of the arches has been lost to a large extent.

No. 3, F. S., 4 years. Pott's disease. Duration of symptoms, five months. X-ray shows involvement of bodies of third, fourth and fifth lumbar vertebrae. Operation, November 26, 1920. Subperiosteal dissection from first to fifth lumbar spines. Lateral articulations were curetted, bridges of bone established between laminae, and spinous processes fractured at their bases and contact made. December 31, 1920, died of tuberculous meningitis, five weeks after operation.

Specimen consists of a segment of spine 11 x 5 x 5 cm. comprising the first lumbar to the first sacral vertebra inclusive. The spinous processes, laminae and lateral articulations of the first to and including the fifth lumbar are fused solidly together. The various elements still are

FIG. 3. (Specimen 1.) Low power photomicograph of vertical section through fused spinous processes.

distinguishable, but the sharp outlines of the spinous processes and laminal bridges have been lost. The remodelling of the bone has progressed to a marked degree. There is evident decrease in the thickness of the disc between the bodies of the third and fourth lumbar and marked thinning of that between the fourth and fifth lumbar. The lower portion of the body of the fifth lumbar on the left side is eroded.

No. 4, S. S., 4 years. Pott's disease. Symptoms first noticed one year before admission. Examined at one hospital and told that there was nothing wrong with spine. Back was then manipulated by a "neuropath". Has had lump on left side for four weeks. Kyphos in upper dorsal region and one in dorsolumbar as well. Entire dorsal and lumbar spine is rigid and muscle spasm is present. There is a mass in left lumbar region and in the left iliac fossa. X-ray shows partial destruction of first and second lumbar vertebrae and possibly a lesion in the upper dorsal and another in the lower lumbar region. Sept. 17, 1915, operation, osteoplastic spine fusion with formation of spinal and laminal bridges from the eleventh dorsal to the fourth lumbar inclusive. Nov.

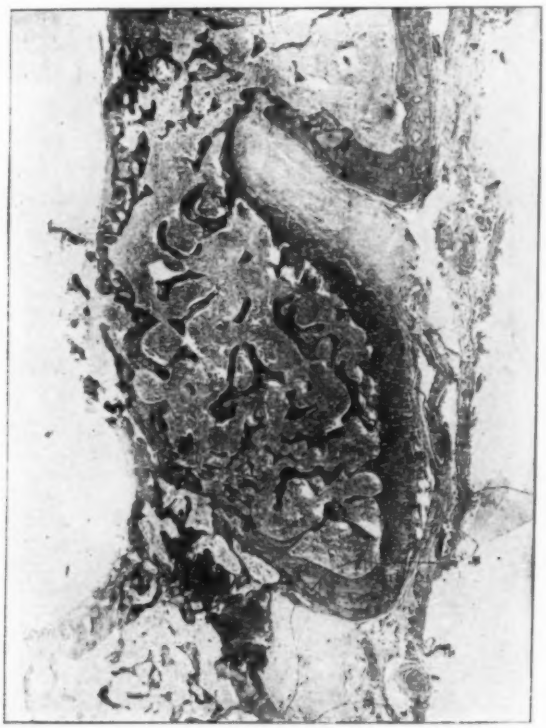

FIG. 4. (Specimen 1.) Photomicrograph showing new bone trabeculae between spinous processes.

25, 1915, patient became seriously ill with signs of pneumonia in left upper lobe. White blood cells 29,000, polymorphonuclears 93 per cent. Later in the day dullness was found on left side from base to angle of scapula. Aspiration of thorax revealed pus. Culture was sterile. Thoracotomy was performed. Nov. 29, patient died, two and one-half months after operation. Autopsy revealed perforation in diaphragm through which the lumbar abscess had drained into the pleural cavity. There was consolidation of the left lung. Section of spine which had previously been fused was removed.

The specimen consists of segment of spine 10 x 5 x 3.5 cm. including what appears to be the bodies of the twelfth dorsal to fourth lumbar and the posterior arches of the eleventh dorsal to the fourth lumbar. The spinous processes, laminae and articular processes of all the vertebrae are fused together in a single column of bone. The spinous processes and elements of bone uniting the laminae can be distinguished, but to a large extent have been melted into a plaque and there is no sharp boundary between the various parts. There is a perforation about

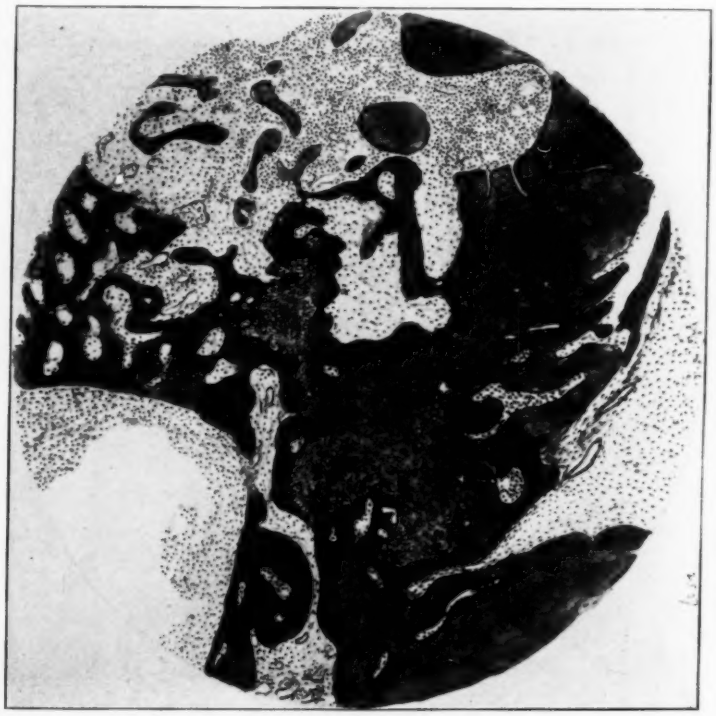

FIG. 5. (Specimen 1.) Drawing of new bone trabeculae between spinous processes. (Higher power.)

3 cm. in diameter through the lamina of the third lumbar at the right of the spinous processes. The intervertebral cartilages are thin. The disc between the second and third lumbar has disappeared and these bodies have been partially destroyed and have collapsed.

No. 5, K. S., 6 years. Pott's disease, with onset four years before admission. Treated on Bradford frame and has worn braces and plaster jackets until six weeks before admission. Kyphos from first to ninth dorsal with apex at sixth to seventh dorsal. Spine rigid in dorsal region. X-ray shows extensive involvement of the fifth to tenth dorsal inclusive with collapse of the bodies down to and including the ninth dorsal. There is thinning of the disc between the ninth and tenth dorsal. The shadow of an abscess is visible at either side of this area. Within the shadow of the abscess on each side is a smaller, deeper shadow, apparently from a calcified mass. Operation, January 3, 1917, incision from fourth dorsal to first lumbar. Spinous processes exposed and periosteum dissected back from spinous processes and laminae, exposing the lateral articular processes. From the fourth to the twelfth dorsal inclusive, the lateral articulations were curetted. The laminal spurs were turned up instead of down, forming the usual bridge. A green stick fracture was produced in the spinous processes from the fourth dorsal to and including the first lumbar and good contact was made. Wound healed by primary intention. March 23, 1917, patient was transferred to the Country Branch. May 26, 1918, succumbed to tuberculous meningitis, one year and four months after operation. Spine removed from area of fusion.

Specimen consists of segment of spine 16 x 6 x 5 cm. including, apparently, the fourth dorsal to the fourth lumbar. In the upper third of the specimen in the region of the sixth to the tenth dorsal, the vertebrae have collapsed, with the production of a kyphos. In the center of this region the anterior ligament has been dissected away from the vertebrae and stands out prominently as the wall of an abscess beneath which the bone is granular. Posteriorly, the ligaments have been removed from the spinous processes and laminae, revealing a fusion of these elements from the fourth dorsal to the first lumbar inclusive. The spinous processes are still to be distinguished but they have been fused into one solid mass with no definite line of demarcation between the various parts. The lateral articulations are obliterated. The posterior arches of the second and third lumbar are separate and unchanged, not having been included in the area of operation.

No. 6, G. W., 7 years old. Pott's disease. Pain in chest for one year following a fall in 1913. Kyphos formed by twelfth dorsal to third

lumbar spines with apex at first lumbar. Large mass in left iliac fossa. Psoas spasm on left side. Operation, February 14, 1914. Spinous processes fractured and bridges of bone constructed between laminae from ninth dorsal to fifth lumbar inclusive. August, 1914, large fluctuating mass has developed over operative area. This later diminished without interference. Deformity progressed, patient's general condition became poor and she died in 1917, three years after operation.

Specimen is a segment of spine 11 x 5 x 3 cm. from the ninth dorsal to and including the third lumbar vertebra. The elements of the posterior arches of the vertebrae are fused together in a bony column which presents a rounded kyphos, the apex of which is formed by the arches of the twelfth dorsal and first lumbar. The bodies of the ninth and tenth dorsal are discrete and are of normal thickness. That of the eleventh dorsal has collapsed into a wedge, and the bodies of the twelfth dorsal and first lumbar have completely disappeared. Their pedicles have

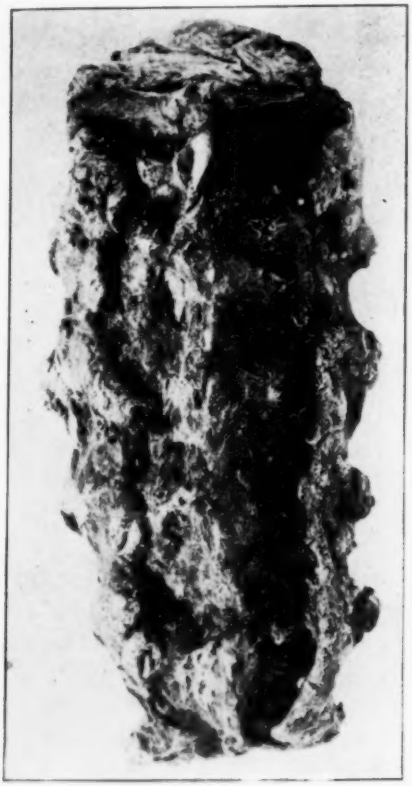

FIG. 6. Photograph of Specimen 3, showing fusion of lumbar vertebrae in four-year-old child five weeks after operation.

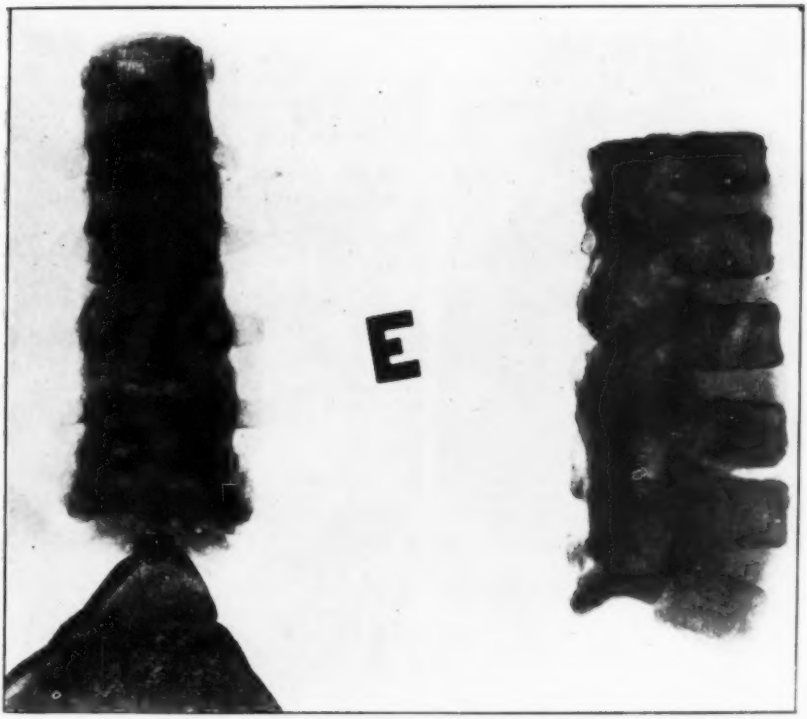

FIG. 7. X-ray of Specimen 3.

united with each other. The body of the second lumbar is represented by a thin plate of bone. That of the third lumbar, although undiminished in thickness, has been invaded by the disease. Across the fused area, between the laminae of the eleventh and twelfth dorsal is a serrated line of fracture, or point at which fusion did not occur. The specimen is thus divided into two parts entirely ununited with each other, the upper consisting of the bodies and fused posterior arches of the ninth to eleventh dorsal, and the lower of the arches of the twelfth dorsal to the third lumbar and the bodies of the second and third lumbar. The anterior surface of the tenth dorsal and the superior surface of the first lumbar bodies, smooth and eburnated, are in contact.

No. 7. *The specimen is a segment of spinal column from a child upon whom a spine fusion operation for Pott's disease was performed. It includes the sixth dorsal to the first sacral vertebrae and is 15 x 5 x 3.5 cm. The vertical alignment of the neural arches is comparatively straight with a deviation of about 1 cm. to the left beginning

at the eleventh dorsal. There is a well marked kyphos with its apex at the twelfth dorsal and first lumbar. From the eighth dorsal to the first sacral the spinous processes and laminae are amalgamated in a single column of bone. Several of the articular processes are fused together, but the majority are not. The ventral portion of the specimen is of particular interest. The bodies in the central portion have been largely destroyed, but the gap between the upper and lower is spanned by a bridge of newly formed bone which extends from the remains of the body of the second to the third lumbar vertebra. There is a sharp offset to the left of the lower lumbar vertebrae, placing them in a different vertical plane from the upper.

No. 8. *The specimen is a segment of spine from the seventh cervical to the third lumbar vertebra inclusive. The bodies of the fourth to the eleventh dorsal inclusive have been largely destroyed and the spine has collapsed in this region with the formation of a sharp kyphos, the apex of which is formed by the seventh and eighth spinous processes. The upper portion of the specimen forms a right angle with the lower. The spinous processes of the fourth to ninth dorsal inclusive, are fused

FIG. 8. Photograph of Specimen 4. Firm fusion in four-year-old child, two and one-half months after operation.

*This specimen was removed at autopsy from a child upon whom a spine fusion operation was performed for tuberculosis. The identity of the specimen has been lost.

together and at the apex of the kyphos the laminae also are joined together in a solid mass. (This specimen is from one of the earliest cases, in which the technic was much less thorough than that now employed. An error was made in not including sufficient vertebrae in the fusion.)

No. 9, C. H., 26 years. Pott's disease, duration of symptoms four years. Both legs paralysed for six weeks prior to admission to hospital. Urgency of urination for four months prior to admission, and loss of voluntary control since onset of paralysis. Admitted to hospital Jan-

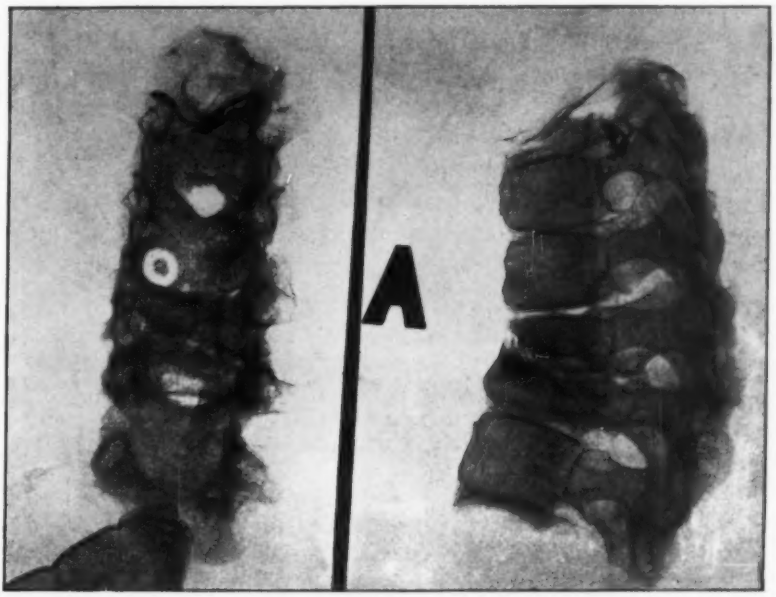

FIG. 9. X-ray of Specimen 4.

uary 19, 1922. Small kyphos consisting of the sixth and seventh dorsal spines. Complete motor paralysis of both lower extremities, loss of sensation to pin-point and touch below a line one inch below the costal margin. Excoriations over both buttocks. January 27, 1922, operation for spine fusion. Incision exposing spinous processes of the fifth to the tenth dorsal vertebrae. Laminae and articular processes exposed subperiosteally. The seventh dorsal spine was very prominent and displaced about one-fourth inch posteriorly. Its laminae were wedged tightly against those of the sixth and eighth dorsal. The operation was completed by making laminal bridges, curetting the lateral articulations and turning down the spines after fracturing their bases. No brace was applied because of the tendency to pressure sore. Patient was placed on an air

bed. In spite of the greatest care, large decubitus ulcers developed on buttocks and patient had high fluctuating temperature for weeks. He died on June 16, 1922, from general sepsis, five months after operation.

The specimen is a segment of spine and cord from the center of the second to the twelfth dorsal vertebra, 22.5 x 6 x 7.5 cm. There is a slight rounded kyphos. From the fifth to the tenth dorsal inclusive, the spinous processes, laminae, and lateral articulations are fused together in a solid bridge. Between the sixth and seventh vertebrae is an irregular crack across the bridge, visible only on forcibly separating the upper and lower parts of the specimen. It is an artefact, having been produced in removing the specimen at postmortem examination. The spinous processes still are distinguishable, but are fused to each other in a strong ridge in the median line, 2 cm. in thickness. The bridges of bone which were turned up and down from the laminae have likewise become melted into a general plaque, but are still distinct. The articulations are represented by knobs of bone, the joint surfaces having been obliterated. The laminae and pedicles of the seventh dorsal are displaced backward. Above and below the area of operation, the elements of the posterior arches are distinct and are movable on each other. The body of the seventh dorsal is almost completely destroyed.

No. 10, D. P., 36 years. Pott's disease. Duration of symptoms four months. Spine rigid. Kyphos from eighth to twelfth dorsal spines with apex at sixth dorsal. Patellar reflexes exaggerated. October 26, 1917, spine fusion from eighth to twelfth dorsal inclusive. May 18, abscess discovered in lumbar region. September, 1918, on flexion of lower spine, there is a sharp pain and muscle spasm suggesting disease below the fused area. There is a discharging sinus from recently drained abscess in lower right lumbar region. X-ray shows disease in twelfth dorsal. Evidently the previous operation, which included only the eleventh dorsal, was not extensive enough to cover the entire diseased area. September 24, 1918, second operation. Fusion extended to include the twelfth dorsal to fourth lumbar. Posterior arches of the tenth and eleventh dorsal vertebrae were exposed and complete fusion of laminae, articulations and spinous processes was found. November 25, 1918, died of miliary tuberculosis, one year and one month after first operation, and two months after second operation. Section of spine was removed at autopsy.

Specimen is a segment of spine 36 x 7 x 7 cm. including parts of the seventh dorsal vertebra and the sacrum and all the intervening portion of the spinal column. There is a dorsal kyphos with the most prominent portion at the tenth and eleventh dorsal and a lumbar lordosis. The

eleventh and twelfth dorsal and first lumbar bodies have been partially destroyed and the intervening fibro-articular cartilages are markedly thinned. Between the eleventh and twelfth dorsal on the left side is a cavity lined with granular bone which apparently communicated with an abscess laterally. Below this and projecting from the left side of the twelfth dorsal and first lumbar bodies is a hard mass about 2.5 cm. in diameter, representing probably a calcified abscess. The disc between the ninth and tenth bodies is thin and the body of the ninth dorsal is diminished in thickness. Posteriorly the spinous process of the seventh dorsal is discrete, but the posterior arches of the eighth dorsal to and including the fourth lumbar are fused together. From the eighth to the eleventh dorsal the fusion is very solid and although the spinous processes and bridges of bone between the laminae can still be recognized as such, they are very indistinct. The bone is quite smooth and the process of remodelling into a homogeneous plaque has gone far. From the twelfth dorsal to the fourth lumbar the column is solid, but the turned down spinous processes and the laminal bridges are still quite distinct and in some cases this amalgamation is not perfectly firm. The articulation between the eleventh and twelfth on the left side has not yet fused, making the column weaker at this point than at any other. The difference between the upper and lower parts of the fused area is due to the fact that the upper was operated upon one year earlier than the lower.

OPERATIVE RECORDS.

Case No. 11, A. C., 2 years and 1 month. Pott's disease. High dorsal kyphos with angular deformity. X-ray shows destruction of bodies of seventh, eighth and ninth dorsal vertebrae. August 23, 1916, spine fusion from fourth dorsal to first lumbar. March 4, 1918, general condition poor, kyphos increasing. X-ray shows marked increase in kyphos. Fusion seems good except between fourth and fifth dorsal which now forms the apex of the kyphos. April 16, 1918, second operation, two years and four months after first operation. Incision made from first cervical to seventh dorsal spines. Fusion from fourth to seventh dorsal was complete. Seventh cervical to fourth dorsal included in area of fusion. It was noted that there was marked mobility between second and third dorsal. October 28, 1918, patient died of influenza.

Case No. 12, L. W., 3 years. Pott's disease. Duration of symptoms two months. Kyphos involving the seventh to tenth dorsal. Muscle spasm is present in dorsal and upper lumbar regions. X-ray shows marked destruction of the eighth and ninth dorsal bodies, and partial

destruction of the tenth. The seventh and eleventh bodies appear not to be involved. June 5, 1917, operation, spine fusion from the sixth to the twelfth dorsal inclusive. Fusion had occurred naturally between the laminae of the eighth and ninth dorsal. November 26, 1919, posture and gait distinctly protective. Unable to determine whether or not there is a pseudo-arthrosis. X-ray shows distinctly the marked increase in kyphos with the center at the ninth dorsal where the disease was most marked in the beginning. When first admitted, involvement was definitely of the eighth, ninth and tenth dorsal. Today the process involves the seventh to twelfth inclusive, with almost complete destruction of all these bodies. Second operation, Nov. 26, 1918, one year and four months after first operation. At operation the old fusion seemed perfect, reaching from the sixth, or possibly the fifth, to the twelfth dorsal. Two vertebrae were added above and below this area. If this fused area bent in forming a greater kyphos, it is the first recognized case. Undoubtedly from the appearance, this is what happened. June 29, 1922, patient is well and free from symptoms.

Case No. 13, S. T., 3 years. Pott's disease. Six months before admission parents noticed hump on back and that legs were becoming weak. There is a slight kyphos with apex at twelfth dorsal and first lumbar. Psoas spasm on both sides. Lumbar lordosis increased. Walks with guarded movement. Left patellar reflex very active. December 2, 1913, operation advised but refused. May 1, 1914, spine fusion performed; subperiosteal dissection from eighth dorsal to fourth lumbar. Spinous processes fractured and bridges made between laminae. October 20, 1916, kyphos appears to have increased. November 10, 1916, exploratory operation, two years and six months after first operation. Region from eighth dorsal to fourth lumbar exposed. Fusion is solid. Spinous processes have been reformed into a smooth column. Patient sent to Country Branch. Discharged cured September 1, 1917. Have been unable to locate him since that time.

Case No. 14, R. G., 3 years. Pott's disease. Kyphos in lower dorsal region. X-ray shows almost complete destruction of ninth dorsal body and partial destruction of eighth and tenth dorsal. January 20, 1915, operation for spine fusion from sixth to twelfth dorsal inclusive. January 16, 1919, patient walks with protective gait and has pain in back. X-ray shows extension of disease above and below fused area. Operation four years after first operation, incision above and below area previously fused. The third to sixth dorsal and twelfth dorsal to third lumbar were added, using the customary technic. Area formerly operated on was

exposed and the vertebrae previously operated upon were found to be solidly united. The spinous processes were welded together, but their outlines could still be made out. January, 1922, no increase in deformity and free from symptoms.

Case No. 15, R. W. K., 3½ years. Pott's disease. Duration of symptoms six months. Slight kyphos from third to sixth dorsal vertebra. Operation December 10, 1913. Spine fusion. Spinous processes and laminae exposed from third to ninth dorsal. Bridges constructed between the laminae. Spinous processes fractured at base and contact established. Symptoms returned in dorsolumbar region in 1916. Second operation May 24, 1916, two years and six months after first operation. Incision made through old scar and extended downward to twelfth dorsal spine. Spinal bridge exposed and found to be completely fused from third to ninth dorsal. The tenth, eleventh and twelfth dorsal were added to the fused area. December, 1917, complains of pain in lumbar region; posture and gait protective. December 18, 1917, third operation. The second lumbar to second sacral vertebrae fused. The area of previous operation from third to twelfth dorsal appears to be completely fused. December 20, discharged relieved.

Case No. 16, D. S., 8 years. Scoliosis following infantile paralysis. December 10, 1919, operation for fusion from fifth dorsal to third lumbar. Spinous processes, laminae and articular processes were united in the fusion. Almost complete fusion in the upper portion of this region was found to exist at the time of operation. January 25, 1921, x-ray shows apparent lack of fusion between the eleventh and twelfth dorsal and between the twelfth dorsal and first lumbar. There appears to be a slight increase in the curve to the left at this point when the patient sits up. Re-operation one year and one month after first operation. Area of former operation exposed and pseudo-arthrosis found between the twelfth dorsal and first lumbar and between the first and second lumbar. Motion was free at these points, but the spine was solidly fused throughout the remainder of the area. Fibrous tissue was removed from the twelfth dorsal and first and second lumbar. Bridges of bone were laid across this area and what remained of the spinous processes was broken down so as to make contact. April 7, 1922, general condition good. Fusion solid with marked curve to the left and with moderate rotation; very slight posterior curve.

Case No. 17, E. D., 11 years. Scoliosis following infantile paralysis. April 2, 1918, spine fusion was performed from second to tenth dorsal inclusive. August 11, 1920, re-operation one year and four months after first operation. There is a marked curve to left with apex at twelfth

dorsal. Area previously operated upon was exposed from the eighth to the tenth dorsal. Spinous processes of the eighth, ninth and tenth dorsal had not been fractured, but the laminae were well fused. Fusion continued to include the third lumbar. April 10, 1922, general condition excellent. Fusion appears to be solid. Posture is very good. General result excellent.

Case No. 18, I. M., 15 years. Patient was operated upon for Pott's disease at the New Jersey Orthopaedic Hospital on February 5, 1916. Spine fusion was performed from the ninth dorsal to the second lumbar by the Hibbs technic. October 13, 1917, patellar reflexes increased. There was marked destruction in lower dorsal region with apex at the ninth and tenth dorsal. November 23, 1917, re-operation, one year and nine months after first operation. Five-inch incision in median line extending upward from the apex of kyphos. Three vertebrae were fused above the area of previous operation. Fusion between the vertebrae previously operated upon was found to be solid. September, 1921, patient died from tuberculous meningitis.

Case No. 19, E. M., 19 years. Pott's disease. Rounded kyphos from third to twelfth dorsal vertebrae. Spine rigid. X-ray shows partial destruction of the eighth dorsal body. July 3, 1916, operation, fusion from the sixth to the tenth dorsal, including the spinous processes, laminae, and lateral articulations. February 7, 1918, upper dorsal region is rigid and attitude protective. No evidence of failure of fusion. There is now a small kyphos with apex at the sixth dorsal just above the sacrum. Second operation one year and seven months after first operation; incision in upper dorsal region, the fourth to the eighth dorsal vertebra being added to the previous field. The eighth, ninth and tenth dorsal were exposed and fusion found to be solid. January, 1921, patient returned to Spain.

Case No. 20, E. L., 23 years. Pott's disease. History of pain in back for one year. Kyphos in lower dorsal region from the eighth to the tenth dorsal. Operation, October 9, 1912. Spinous processes from the ninth dorsal to the second lumbar exposed. Fusion was found to be present between the eleventh and twelfth dorsal and between the first and second lumbar vertebrae. The spinous processes from the ninth dorsal to the second lumbar were fractured at their bases and contact

established between them. May 28, 1918, x-ray shows marked destruction of the eleventh and twelfth dorsal and first lumbar bodies. The ninth and tenth dorsal and probably the eighth, and the second lumbar are also involved. Re-operation five years and seven months after first operation. Incision from the ninth to the twelfth dorsal and from the second to the fifth lumbar. Operation for fusion by the usual technic was done from the ninth to the eleventh dorsal and from the second to the fifth lumbar. Fusion was found to be perfect from the eleventh dorsal to the second lumbar. June 19, 1922, patient is well and free from symptoms.

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FLATTENED HIP SOCKET AND ITS SEQUELAE.

(Coxa Plana, Valga, Vara, and Malum Coxae).

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The femoral head and neck, when being deformed to the condition which was first described by Dr. Legg, pass through the following phases:

Fig. I
Normal femoral head and neck.

Fig. II
Initial stage of coxa plana.

Fig. III
Coxa plana.

Fig. IV
Fragmented stage of coxa plana.

Starting from the normal condition, represented by Fig. I, the growth-disc is seen to approach the horizontal position (Fig. II). The femoral head and growth-disc rotate, the formation of bone increasing on the medial, decreasing on the lateral side. At the same time a "chin"-shaped protrusion develops on the mesial side at the site of increased bone formation. Moreover, the head often shows a lateral displacement, the lateral border protruding beyond the lateral side of the neck ("head-in-neck"-position). In the growth-disc, which normally lies in an even plane, an irregularity often develops during the rotation and displacement of the head, mostly pointed and directed downwards. All these phenomena precede tne more striking symptoms to which the condition owes its name. In other words the rotation of the growth-disc, its lateral displacement, the "chin" and the pointed irregularity in the growth-disc initiate coxa plana, constitute the *initial stage of coxa plana.* (Fig. II.).

Under circumstances which will be studied later on, the deformation of femoral head and neck into coxa plana may come to a stand-still in any stage, also during the development of the initial phenomena. If these circumstances do not present themselves, the flattening of the head, which becomes noticeable even during the initial stage, gradually increases. At the same time it widens out. The neck also widens out, more in its upper than in its lower part. All this is attended by a shortening of the vertical dimension, not only of the femoral head, but also of the neck. During this broadening and flattening (shortening) of head and neck the pointed irregularity in the growth-disc disappears, the growth-disc spreading out in a curved plane parallel with the surface of the head. Coxa plana then has reached the *complete stage.* (Fig. III.).

The form of coxa plana, however, which has been most discussed, exists only when, after progressive flattening of femoral head and neck, the bony part of the head appears to be divided into pieces by translucid areas. The condition might be termed *coxa plana fragmentata* or the *fragmented stage of coxa plana.* Experience has taught that trauma may be helpful in producing the condition, as well as some intercurrent disease, but it may also develop without any traceable cause.

On further growth the bony parts in the femoral head reunite, and in the adult, after ossification of the growth-disc, they form a broad, flat, pear-shaped whole with the femoral neck.

The development of the three stages of coxa plana is restricted to the first ten or twelve years of life. Roughly speaking, the first six years may be said to be spent on the initial stage, the remaining ones on the flattening, widening, and fragmentation. As has been observed, the development of the phenomena may come to a stop in any stage, even in the initial stage. Moreover, the form of *incomplete coxa plana* may undergo certain modifications in after years, but the excessive flattening, shortening, and widening of head and neck and the fragmentation of the head are not seen to develop later on. This fact, too, will have to be taken into account in the explanation of the phenomena

FIG. V
Normal socket
The socket fits round the head. (Socket-line and outline of head run parallel.)

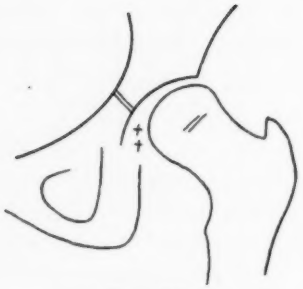


FIG. VI
Flattened Socket
(Through a too thick socket floor).

FIG. VII
Widened Socket
(Through ischium varum.)

In flattened socket and in widened socket—or shortly: in flattened hip socket—the socket does not fit round the normal head. (Socket-line and outline of head do not run parallel.) The relation of "cup and saucer" exists: there is a gap ‡. A too thick socket floor implies subluxation (lateroposition) of the femoral head; ischium varum does not.

Certain characteristic changes in the hip-socket, which regularly attend the above phenomena of femoral head and neck, have hitherto escaped the attention of investigators. In all our cases, as well as in those represented in literature which justified a conclusion, we have found either the *floor of the socket too thick, with, therefore, the hip-socket too shallow* (Cf Figs. V. and VI.), or we have found the os ischii running obliquely, its lower end swung mesially, the centre of the hip-socket being the turning point—a condition we have termed *ischium varum.* The lower part of the hip-socket in ischium varum thus appears to have shared the rotating displacement of the ischium. The socket is *too wide.* (Cf Figs. V. and VII.).

Both in the case of a too thick socket-floor and of ischium varum the x-ray plate shows a socket-line with too wide a curve, as if drawn with too large a radius, and the socket may be considered as part of a sphere too large for the femoral head. Both the shallow and the wide socket may be therefore spoken of as *flattened socket.*

Now the flattening of the hip-socket entails considerable alterations in the mechanical relations between femoral head and neck, and in the following pages the development of the phenomena of coxa plana will appear to be the natural outcome of these alterations.

While normally the hip-socket surrounds the femoral head like a close fitting cup, in the flattened socket only small portions are in contact. The condition may be roughly compared with the relation between a cup and a saucer. In the erect posture the femoral head is in contact only with the upper portion of the flattened socket, a gap being left between the mesial part of head and socket. (It is understood that the upper portion of the socket is normal, running practically in a horizontal direction.) The functional stresses which are normally transmitted from the whole of the socket surface to the femoral head, or reversely, are thus concentrated over a small area in the upper part of the socket.

Normally the centre of the femoral head is the fixed point which never moves with regard to the socket, and forms the turning point of all movements. In the flattened socket, however, this is different. The turning point is displaced to the area of contact between head and socket roof, in which, moreover, sliding movements are possible. While normally the functional stresses press the head more firmly against the whole of the socket surface, here the femoral head can be pressed more firmly only against the small area of contact. Now, all stresses which cause a rotation of the femoral head, i. e., those which do not pass

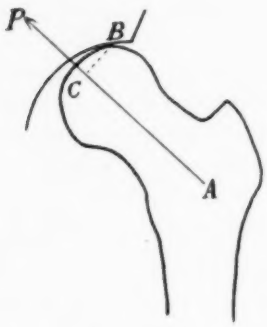


FIG. VIII

All forces (A P) that act upon the femur, and that do not go through the area of contact B, strive to rotate inward and upward the part of the head which is situated mesially to B. (Cf Fig. IX.)

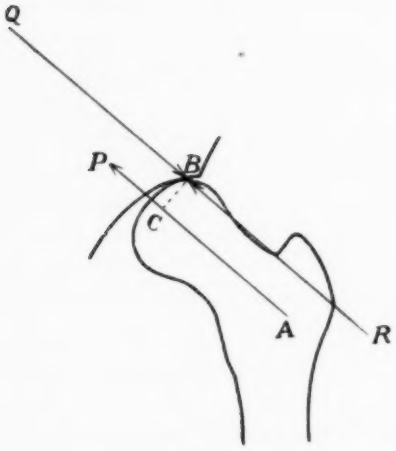


FIG. IX

The muscle forces develop a couple of forces=A P× B C Moreover, the horizontal component of B R produces a displacement of the femoral head; the vertical component assists the couple in compressing head and neck.

through the area of contact between head and socket, develop a couple of forces which must tend to cause a very characteristic deformation of head and neck.

If in Fig. VIII. AP be the force and B the area of contact between head and socket, the point around which rotation takes place, then AP $\times$ BC is the moment with which AP strives to displace upward and mesially the part of femoral neck and head situated below B.

Suppose instead of the point B a point of the lower part of the femoral head below AP were in contact with the socket. Then the force AP would tend to cause a rotation in a direction opposite to that of Fig. VIII. In the normal socket these rotatory stresses balance one another. In the flattened socket, however, this balance is disturbed, since the contact between the lower part of head and socket is lacking. Hence, in flattened socket only the moment of the force AP of Fig. VIII. can manifest itself.

The action of AP may be determined more precisely, if to Fig. VIII. two equal forces, but opposite in direction, are added, meeting in B and parallel to AP, which, of course, may be done without altering the mechanical condition of the whole. (Cf Fig. IX.) It then appears that besides the couple of forces = AP $\times$ BC acting on the femoral head and tending to produce rotatory stresses, a force BR is acting. BR may be separated into a vertical and a transverse component. The horizontal component tends to shove the head mesially; the vertical one simply presses the head against the socket roof.

This reasoning may be applied to all muscular forces which act on some part of the femur, and are directed either below and above B.

Thus the flattened hip-socket alters the mechanism of muscle-function so that three groups of forces must be considered to act on the femoral head and neck:

1° *a couple of forces* which strive to rotate head and neck, moving the mesial part upward, the lateral part downward.

2° *horizontal forces* which tend to cause the head to slide mesially.

3° *vertical forces* passing through the restricted area of contact—exerting a pressure which is reinforced by the power of gravity.

Now, each of these three groups of forces seem to be responsible for part of the phenomena in coxa plana.

It can, indeed, hardly be mere chance that each of the three groups

of phenomena by which coxa plana is characterized corresponds to one of the above groups of forces:

1° the rotation of the head, which leads to the horizontal position of the growth-disc, corresponds to the action of the couple of forces;

2° the lateral displacement of the head corresponds to the horizontal component of the acting forces:

3° the flattening, shortening, and widening out of the femoral head and neck corresponds to the vertical component which acts on the area of contact and is reinforced by the power of gravity.

In a Study "Feebleness of Growth and Congenital Dwarfism," we have tried to prove that, if functional pressure acting on bone tissue exceeds certain limits, decrease of *growth* may result. This decrease is not observed in perfectly normal, unenfeebled children, however much the stresses of function may be increased. But decrease of growth under functional stresses does present itself in children on whom injurious agents have been acting and whose power of growth has thus been enfeebled. This enfeeblement of the power of growth is, as may be understood, proportional, not only to the intensity of the injurious agent, but also to the rapidity of growth (Law of the vulnerability of fast growing cellgroups). Decrease of growth to increase of pressure, therefore, presents itself sooner and more in proportion as the children are younger, and first and mostly in the vicinity of the growth-discs.

In a study "On Bone formation" we have adduced grounds for the assumption that bone, when exposed to functional stresses which exceed a certain limit, will absorb lime-salts and become plastic. This plasticity also presents itself sooner in proportion as the individual has been more enfeebled by injurious agents and it stands to reason that traumatised bone will develop plasticity even through normal weight-bearing when this is applied too early.

Thus in children who have been enfeebled by injurious agents, the functional stresses of muscle action and body weight may retard the growth of bone, and also alter the shape of bones once formed. This occurs soonest and to the greatest degree at times and in areas of rapid growth.[1]

If we compare the initial stage of coxa plana of Fig. II. with the normal femoral head of Fig. I., which are both copies from x-ray plates, by superposing tracings on transparent paper, the circumference of the two appears to differ but little. The head of Fig. II has rotated, it is

(1) For a more complete introduction into the rules of bone-growth and bone-formation, we must refer to the books mentioned.

true, but it is little higher or lower than it should be. The lines of the growth-discs cross. So, on the inner side of the neck where the "chin" has developed, more bone has been formed than normally; on the outer side, where the neck is shortened, the quantity of bone formed lags behind the normal.

In the shallow hip-socket, as well as in the wide, the area of contact between head and socket is situated over the *lateral* part of the growth-disc. So, through this small area the vertical stresses of muscle-action and body-weight are concentrated in addition to those evoked by the couple of forces. The lateral part of the growth-disc in the femoral head, therefore, is made to bear excessive weight. So it cannot cause wonder that there growth is retarded in a way which reminds us of that on the lateral side of knock-knee. The increase of the amount of bone near the mesial part of the growth-disc indicates increased growth in that region through decrease of pressure or—in case of total absence of pressure—possibly also indicates a lengthening of bone once formed under the action of the couple of forces. This lengthening would in the latter case be comparable to the lengthening of the trochanter major in serious cases of coxa vara, when it is made to resist tension stresses exclusively (Cf. "On Boneformation" l.c.).

The degree of enfeeblement of a child (and consequently of its power of growth) necessary to cause the rotation of the head, is surely slight: it is, indeed, observed in individuals in whom there is no question of knock-knees. *i. e.*, in whom the enfeeblement of the power of growth is limited to the muscles and becomes manifest only in flatfeet, prominent abdomen, round back and acrocyanosis and hyperhydrosis. It is well known that the growth-discs near the knee add more to the length of the leg than those near hips and ankle. In a child with normal hip-sockets we accordingly see that decrease of growth to increase of pressure is observed sooner near the knee than elsewhere in the leg. In case of flattened socket, however, there is an exception to this rule, the growth-disc in the neck showing decrease of growth to increase of pressure sooner than the growth-discs near the knee. And this must be accounted for by the fact that all functional stresses are concentrated on a much smaller area, the lateral part of femoral head, growth-disc, and neck.

The question arises whether these stresses may also cause the rotation of the head and growth-disc in perfectly normal, unenfeebled individuals. In perfectly unenfeebled bones, as has been stated in the above, decrease of growth to increase of pressure has not been observed as yet. That is why a certain amount of enfeeblement of the individual

—it may be a slight one—has to be considered a probable condition for the development of coxa plana. The rotation of the femoral head and neck may be considered apart from growth as a simple mechanical occurrence. Growth-disc and adjoining parts then appear in coxa plana as an area of lessened resistance. Needless to say that even this lessened resistance is not observed in normal individuals. Thus we are led to assume that in a perfectly unenfeebled individual all parts of the femoral neck will respond equally to the stresses evoked by the couple of forces, i.e., that the moment of the couple will tend to rotate the whole of the femoral neck laterally, to place it in a valgus position eventually in an upright position. The shortening on the lateral side and lengthening on the mesial side of the neck then will be distributed equally over the whole of the length of the neck. We have indeed observed cases of coxa valga combined with flattened socket (ch. Figs. XXXI., XXXII. and XXXIII. However, we have not yet seen any coxa valga *develop* from the normal femoral neck, and therefore cannot decide in what measure coxa valga has to be considered as a congenital malformation or as one brought about in postnatal life by a primary congenital flattening of the hip-socket. At all events, *it must be deemed possible that flattened hip-socket in unenfeebled individuals may lead to the development of coxa valga.* And the characteristic horizontal position in the growth-disc in coxa valga appears as an initial symptom of coxa plana. Possibly, therefore, coxa plana and certain cases of coxa valga have a common cause in a flattened hip-socket. If so, it is the degree of enfeeblement of the power of growth which in cases of flattened hip-socket may decide whether one or the other condition will develop.

In the following pages we shall try to show that besides the degree of enfeeblement of the power of growth the presence of a primary valgus-position of the femoral neck—it may be slight and within normal limits—lessens the moment of the couple, thus also the chance of a rotation of the head and growth-disc, and with it of the development of coxa plana.

The irregularity of the growth-disc in the initial stage of coxa plana, with the point directed downward, justifies on account of its characteristic form the assumption that it is caused by mechanical stresses, possibly by the couple of forces. At all events, it is seen to disappear in the later stage of flattening and widening of head and neck. Then indeed the enlargement of the area of contact between head and neck not only enhances the resistance against rotation of the growth-disc, but it also lessens the action of the couple which tends to cause this rotation. This may be demonstrated by drawing a line coinciding with

the axis of the femoral neck in Figs. II. and IV. It may then be inferred that a force thus acting in Fig. II. may be able to cause rotation of the head, since it acts outside the area of contact with the socket, whereas in Fig. IV. it will pass through the enlarged area of contact and thus be unable to cause rotation. Be this as it may, this consideration explains why the rotation of the growth-disc in coxa plana stops when femoral head and neck have sustained a certain amount of flattening and widening, viz., mostly at the time when the growth-disc under the evenly flattened head runs parallel to the socket-roof.

That the *horizontal component* of the acting forces tends to cause a lateral displacement of the femoral head need hardly be mentioned. The muscles which produce it are attached to the femur below the head near the trochanters, and every displacement of the head in a mesial direction alongside the socket-roof is bound to evoke shearing stresses in the region of the growth-disc which will tend to displace it laterally.

If the femoral neck could be displaced mesially a long distance, the head might possibly be shoved off the neck altogether. The neck, however, will long before butt against the mesial (i.e. ischio-pubical) portion of the socket with its inner surface, the region of the "chin." And with this mesial contact the mutual co-aptation of the joint-surfaces is introduced. The inner part of the head then is squeezed between the mesial portion of the socket-roof and the femoral neck. It consequently often adopts a pointed shape on that side, different from its round lateral contour, thus adapting itself to its surroundings.

It must be admitted that an injury to the blood-vessels is apt to occur during this displacement of the epiphysis, which is *no norum* in the affections of the femur, as well as during the development of the irregularity in the growth-disc. And the supposition is justified that the relative scarcity of limesalts, which the entire head sometimes shows in the initial stage, may be the result of such vascular lesions. Be this as it may, the displacement of the head constitutes a traumatic factor which may enhance the plasticity of adjacent parts, and create a condition comparable to too early weight-bearing of callus after fracture. And this trauma has to be considered, besides the two above mentioned rules for bone-growth and formation, as the third factor determining the development of coxa plana.

The *vertical component* of the muscle-forces is strengthened by the power of gravity. The femoral neck is simply seen to shorten and widen out like plastic material which is made to bear pressure from above. The distance between the growth-disc and the trochanter major gradually lessens and disappears, while the thickening of the neck causes the fossa trochanterica to rise, so that the trochanter itself becomes smaller

and smaller. It would indeed be difficult to deny in this widening and shortening of the femoral neck and head the activity of the vertical stresses. On the contrary, it seems plausible to consider it the outcome of plasticity of bone under the influence of relatively high pressure.

The broadening of the neck, and therefore also the shortening, first shows itself near the growth-disc. In its transition into the completed form of coxa plana the upper portion of the neck regularly shows more increase in width than the lower portion. The great mechanical changes near the growth-disc thus seem to enhance the plasticity of its surroundings. In agreement with this the region just below the growth-disc often shows the translucid area first described by Waldenström. The plasticity gradually appears to spread. But in every stage of the widening and shortening of the neck the upper region presents more considerable widening than the lower, i.e., the neck appears pear-shaped.

In agreement with the supposition that vascular injuries near the growth-disc contribute to the plasticity of the femoral neck, is the fact that the considerable widening of the neck starts only after the deformation of the growth-disc or also the displacement of the head; as well as the fact that in coxa valga, in which the lateral displacement of the head may be lacking altogether, the deformation is limited to slight flattening and very often to doubtful widening of the neck in the vicinity of the growth-disc (Cf. Figs. XXXI., XXXII. and XXXIII.). However, in coxa valga other factors tend to protect the neck from shortening and widening out, viz., the more equal participation of the convex and the concave-sided bone elements in the neck in bearing the pressure. This point will be dealt with later on. Here it should be emphasized that both the translucency and the plasticity are strongly suggestive of the reaction of traumatised bone to early weight-bearing.

As during the development of coxa plana the femoral neck becomes wider and wider, head and growth-disc are spread out over an ever increasing area. The head thus becomes thinner and adapts itself with the growth-disc to that portion of the socket with which it is in contact. It can cause no wonder that during this ever increasing extension of the head translucid patches, like rents in the bony parts of the head, become visible (*coxa plana fragmentata*). And the connection with mechanical forces makes itself felt in that these rents often present themselves where the plane of the growth-disc shows a bend or curve.

All in all, the study of the x-ray plates of coxa plana presents no phenomenon which is opposed to the assumption that flattened hip-socket is its primary cause. On the contrary, with this assumption all phenomena admit of an explanation according to rules of mechanics, bone-

formation, deformation and growth. Therefore, there is every reason to assume that *flattening of the hip-socket may cause flattening of the femoral head.*

For completeness' sake it must be mentioned that in ischium varum the ischial and pubic bones are not always displaced mesially to the same extent. We meet with conditions in which the x-ray plate justifies the assumption that the os ischii has been rotated mesially more than the os pubis. The x-ray plate then shows the spina ischii on the mesial side of the linea innominata, although the exposure has been symmetrical. In other plates the pubis appears to be relatively more displaced than the ischium. In all these cases the hip-socket is not only too wide or too flat; it is, moreover, *wry*. It stands to reason that, when, for instance, in ischium varum the os pubis shows signs of more mesial displacement than the os ischii, this *twisting* of the socket enhances the incongruence of the articular surfaces and lessens the chance of satisfactory functional co-aptation. The twisted or *wry socket*, however, does not essentially affect the above considerations.

If in the above the explanation of coxa plana has been reduced to that of a congenital malformation of the hip-socket—viz., a widening through ischium varum or also a flattening through a too thick socket-floor—it will now be our task to trace the cause of these congenital malformations.

It is well known that coxa plana is a satellite of congenital dislocation of the hip. It is often observed in the same individual, one hip being dislocated, the other affected by coxa plana; or in the same family, for instance, congenital dislocation of one or both hips in the mother, and coxa plana either on one or on both sides in the child. Coxa plana develops with relatively high frequency after reduction of congenital dislocation. The explanation of ischium varum and a too thick socket-floor will, therefore, at the same time have to lighten up the correlation with congenital dislocation of the hip.

Le Damany has brought forward grounds to assume that the amniotic sac which lags behind in growth after the development of the extremities may flex the hip of the foetus to excess and lever the femoral head out of its socket, the pelvic border acting as a fulcrum, and thus cause congenital dislocation of the hip. If the pressure exerted by the amnion is less intensive, it may be just strong enough to lessen the pressure of the femoral head against the socket-floor, so that the normal deepening of the socket is prevented and a too thick socket-floor results. In other cases the narrow amniotic sac may be drawn too tightly over the ischial bones, and bend them both inward, if the pelvis is lying symmetrically, or deform one of the ischia only, if the pelvis is not lying symmetrically

but lower on that side. Thus flattened hip-socket, either through ischium varum or a too thick socket-floor, may be ranged among the congenital deformities, caused by smallness of the amnion.

Elsewhere we have adduced arguments for the assumption that besides dislocation of the hip other congenital malformations, as achondroplasia, club-foot, etc., may be brought about by smallness of the amnion. It therefore, need not cause wonder that these conditions have been observed with congenital dislocation and coxa plana in the same family and even in the same individual.

Of the causes of smallness of the amnion, little is known. It may probably result from inflammations of the maternal mucous membranes and also from cold. In a large number of cases, however, it presents itself as an hereditary factor with unknown cause. For all that, the above considerations may have the advantage of marking the direction in which both the prevention and the treatment of coxa plana have to be sought.

If in the preceding pages the development of coxa plana has been sketched, it may have become patent that its nature is a diminution resp. the abolition of a congenital incongruence of the articular surfaces. And secondary changes which, moreover, often develop in the socket itself, bear the same stamp. In this light it may be understood:

1° that the development of coxa plana is confined to childhood. The plasticity of bone, indeed, decreases with the rapidity of growth in agreement with established rules;

2° that coxa plana may heal spontaneously, viz., when the congruence of the articular surfaces has been reached;

3° that in case of slight incongruence of the joint surfaces the development of coxa plana may stop in the initial stage;

4° that in case of serious incongruence or of hard bone tissue (i.e., in unenfeebled individuals) the co-aptation of the articular surfaces remain incomplete, and symptoms of joint-wear ("osteo-arthritis") may develop in after-years;

5° that enfeebling influences, for instance, diseases and traumata, promote the development of coxa plana.

A few cases of flattened socket may serve to test and to illustrate the above considerations:

A. Cases *with flattened socket*, i.e., with *a too thick socket-floor;*
B. Cases *with widened socket*, i.e., with *ischium varum.*

A. Cases with a too thick socket-floor;

In the first place, Figs. X. and XI., which belong to the rare cases which have been observed both before and during the fragmentation

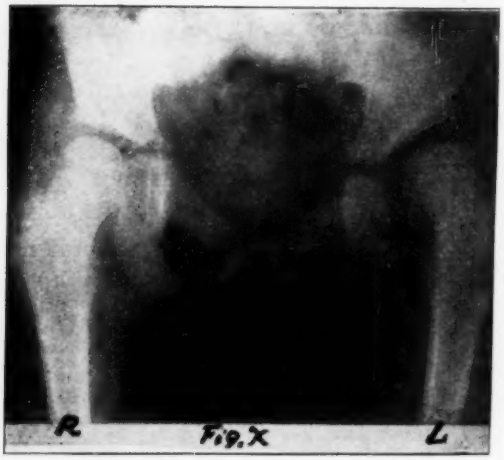
stage.[2] Fig. X., boy, 7 years. The socket-floor is too thick on both sides: the curved line which we will term *socket-line*, is, in its middle—the cartilaginous centre of the socket-floor—too wide apart from the linea innominata. In other words: the strip of cartilage which unites the socket-line and the linea innominata is too long: more even on the left than on the right side. On both sides lateropositio coxae or subluxatio coxae results, the lateral border of the femoral neck being lateral of the lengthening of the lateral border of the os ilii; also more on the left than on the right side. On both sides the femoral neck is too high, the inner border being higher than the lengthening of the upper line of the foramen obturatum. *On the right side the initial stage of coxa plana exists.* (Cf. Fig. II.: the horizontal growth-disc with the irregularity, the "chin" on the mesial side of the neck, the lateral displacement of the head, and the slight flattening.) The outlines of head and socket here run practically parallel, so the co-aptation is rather accurate, and little or no increase of the flattening of the head need be expected in the future. On the left *coxa plana* is present, although in a moderate degree. Mesially and lower down, the distance between head and socket enlarges (Cf. Fig. VI). Both on the right and on the left the femoral neck is widened out, most obviously near the growth-disc.

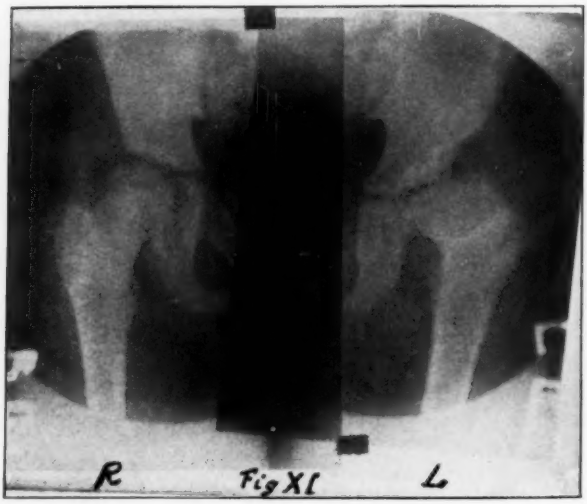
Fig. XI., the same boy, 4½ years later, 11½ years old. The right side has maintained the initial stage of coxa plana. The latero-position exists unaltered. The mesial part of femoral neck and head now seem to transmit the oblique and transverse stresses to the mesial part of the socket: the "chin" more accurately imitates the spherical form of the socket than in Fig. X., and has lost its translucency, its shortage of lime-salts, which is patent in Fig. X. On the *left* side *coxa plana fragmentata* has developed with the excessive widening out of the neck.

If we compare the direction of growth-disc and femoral head of Fig. X. with that of Fig. XI., in the latter the original horizontal position appears to have been lost. To this phenomenon the too thick socket-floor is for obvious reasons more apt to lead than ischium varum. The conclusion seems justified that since the time when the growth-disc assumed the horizontal position the direction of the socket-roof has been modified. A beginning of this change seems to be present even in Fig. X. The action of the couple of forces, indeed, which is obvious in all our other figures, cannot be constructed here.

The flattening of the left femoral head in both figures reaches beyond the bony socket-border. In this the cartilaginous socket-border, as well as abduction movements and mesial displacements of the head along the socket-roof, may have had a share.

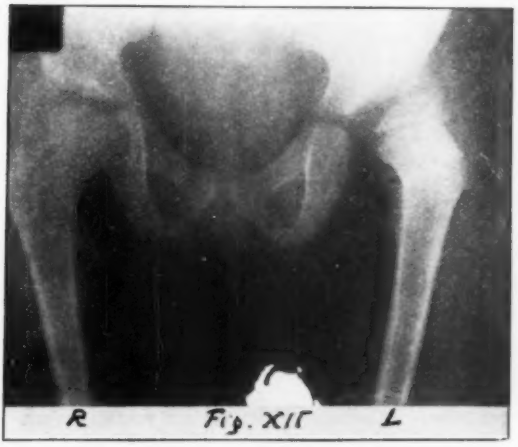
(2) Cordial thanks to Dr. Havinga, who put them at our disposal.

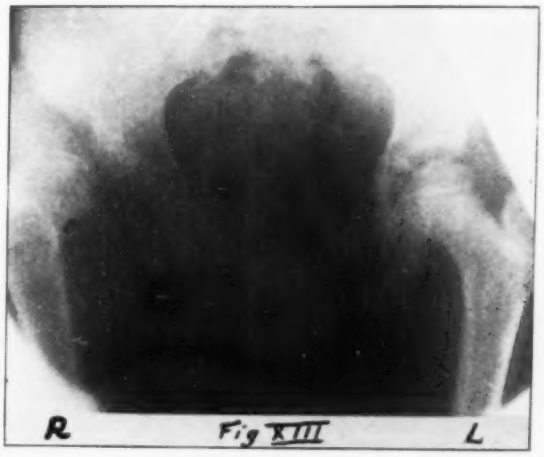




Calot has taught that the upward direction of the socket-roof, the lengthening of the hip-socket in its upper part, has to be considered as the condition for the development of coxa plana. Fig. XI. shows on the contrary that it rather tends to alter the characteristic form of coxa plana, enhancing the chance of an increase of the subluxation and an upward displacement of the femoral head without the characteristic flattening. This may be illustrated by Figs. XII. and XIII.:

Fig. XII., G. S., girl, 4 years, reduced congenital dislocation. Fig.





XIII., H. d. H., girl, 7 years, also reduced congenital dislocation, treated elsewhere. Both show the thickened socket-floor and the sloping socket-roof. The oblique flattening of the head and the thickening of the neck in these cases bear testimony to the amount of stress which presses the femoral head mesially against socket or ilium. They prove that modified mechanical stresses are sufficient to cause flattening of the head and thickening of the neck, i.e., they give evidence of the plasticity of bone under abnormal pressure. The deforming process in the bone tissue here bears the stamp of a co-aptation, and as such it is essentially the same as in coxa plana; only the characteristic shape of Figs. II., III., and IV. is not brought about, because the direction of the stresses is different.

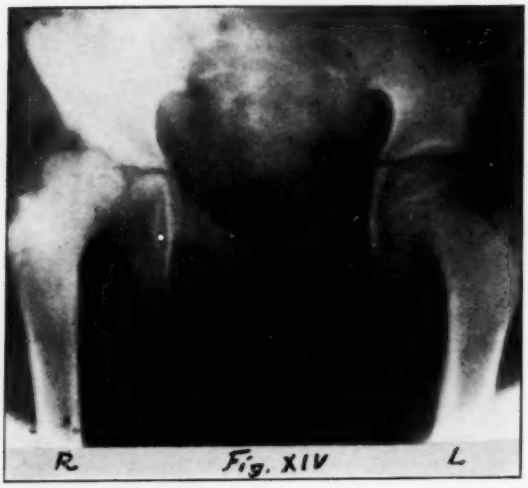


Fig. XIV

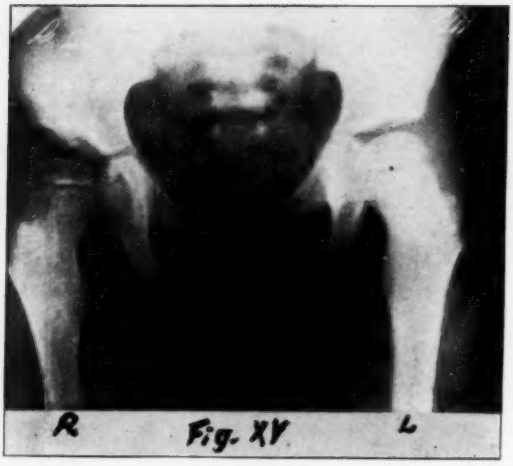


Fig. XV

Even those who would assume a bacterial focus acting in these cases would not be able to deny to the pressure against the pelvis a share in the deformation. However, there is no reason for the assumption of a bacterial focus any more than in our other figures. They are all taken from perfectly healthy individuals.

The sloping socket-roof thus yields a contribution to the knowledge of the plasticity of bone under abnormal mechanical stresses and indirectly also to that of the development of coxa plana.

Figs. XIV., P. S., girl, 9½ years; XV., L. d. K., girl, 11 years and XVI., C. S., girl, 9 years, all show the initial stage of coxa plana on the right side (Cf. Fig. II.). Figs. XIV. and XVI., moreover, show shortening and thickening of the femoral neck more obviously than Fig. XV. They are all reduced congenital dislocations with thickened socket-floor and resulting latero-position. They are the perfect likeness of Fig. II., which has passed into the fragmented stage later on.

Note the shortage of limesalts in the region of the "chin," which justifies the supposition that this part of the femoral neck does not yet transmit the stresses from the neck to the socket and reversely.

The flattened head of Fig. XVI. shows translucid areas. Figs. XIV. and XV. do not show them any more than Fig. X. So they are not constant and therefore have no causal meaning for the development of coxa plana. They may have been produced by irregularities in the acting stresses in connection with irregularities in the articular surfaces or by vascular lesions due to the rotation and displacement of the head, or by both. They are areas of lessened resistance which probably promote fragmentation.

Note that the socket-line on the right side in all three, Figs. XIV., XV. and XVI., as well as the one on the left in Fig. X. in consequence of the too thick socket-floor, describes a wider curve than the corresponding femoral head. The socket-line seems partly stretched. If the completed and the fragmented stage leave some doubt as to whether

the flattening (or widening) of the socket is primary, the widening of the femoral head secondary, *the initial stages of coxa plana show that the widening of the socket is present even before the widening of the head, i.e., that in coxa plana the flattened socket is a primary factor.*

B. Cases with widened socket, i.e., with ischium varum.

Fig. XVII., boy, 7 years, owes the excessive width of his right acetabulum to *ischium varum.* The right os ischii runs obliquely from above and outside down and inward. It has, so to speak, been rotated inward with the centre of the acetabulum as turning point. The lower—ischial and pubic[3]—part of the socket thus has rotated with the ischium with regard to the upper—iliac—part, so the acetabulum appears indented in its cartilaginous centre, a gap being caused between the lower or ischio-pubic part of the socket and the femoral head. This is the gap we consider to be responsible for the development of the couple of functional forces which cause the rotation of head and growth-disc, the displacement of the head and the widening and shortening of femoral head and neck.

Ischium varum has hitherto remained unobserved, because asymmetries in the x-ray plate of the ossa ischii and foramina obturata are involuntarily, almost unconsciously, dismissed by the student, being

(3) The pubic part of the socket line runs—as is well known—in the lengthening of the iliac part. The shadow of the ischial part extends more laterally, and normally partly coincides with that of the femoral head.

attributed to asymmetry in exposure and therefore considered meaningless. Note, therefore, that the varus position of the ischium is present in these as in the following figures, although the other parts of the pelvis show almost perfect symmetry. And especially the greater width of the socket-line on the side of ischium varum, compared with that on the sound side, testifies that the asymmetry is not due to asymmetrical exposure. Nor is it possible to obtain monolateral ischium varum in the x-ray picture with a normal pelvic skeleton. This may be shown by studying the shadow of a skeletal pelvis under the glowing body of a Coolidge tube. It is true, in the normal living body, the whole of the ilium may be displaced in the sacro-iliac joint, and this may be shown in the x-ray plate on very asymmetric exposure, as has been pointed out to us by Dr. Steenhuis, our Leiden röntgenologist, in one of our medical meetings. In that case, however, ilium and ischium have moved together; and the indentation of the acetabulum, th widening or partial stretching of the socket-line, is lacking.

Observe that in Fig. XVII. the os ischii, besides occupying a varus position, is also dwarfed, a fact which does not depend on asymmetry of exposure any more than the varus position, but may also be explained by enhanced amniotic pres ure (Cf. "Achondroplasia: its Nature and its Cause").

Fig. XVIII., boy, 4 years, shows coxa plana fragmentata on the right side attended by ischium varum.

On the left side the varus position of the ischium is doubtful. The socket-floor is not too thick. In the pubic part of the socket-line, however, there is an indentation reaching too far mesially. So the left

socket is probably wry, which may aggravate eventual consequences of the doubtful varus-position of the os ischii. The incongruence on the left side, however, is much less than on the right, and, in connection with this, coxa plana on the left side has not even completed the initial stage.

By the way, we observe that on the side of coxa plana the femoral shaft is regularly thinner and mostly also more translucid than on the normal side. This pleads in favor of the assumption that the functional stresses on that side are always less, and hence the flattening and widening develop notwithstanding the fact that in an absolute sense the stresses of function are less than normally. The bone in which coxa plana is developing, appears to be spared. The rotation of the growth-disc cannot be considered a sufficient reason for any such restricted use any more than f. i. in the developing knock knee. It, therefore, starts probably at the moment when the displacement of the head or the deformation of the growth-disc has made itself felt as a trauma, and changes in the gait become manifest which lead the patient to the doctor.

Fig. XIX., M. V., girl, 2½ years, shows left coxa plana which has developed 2½ years after reduction of left congenital dislocation. The left socketline is almost entirely stretched in its pubic portion by a marked ischium varum and nanum. Its upper portion slopes upward in the way described by Calot. The femoral head seems to have absorbed all its limesalts. The form of the flattening of the head departs from the characteristic coxa plana (Cf. Fig. IV.). However, it appears to have been determined by mechanical conditions in this as in other cases, the lines of head and socket running practically parallel. And *this regular coincidence of the form of coxa plana and the direction of the*

mechanical stresses acting upon it, constitutes one of the claims for the assumption of the mechanical cause.

Fig. XX., K. L., boy, 3½ years, and Fig. XXI., H. d. W., girl, 4 years, both show the initial stage of coxa plana on the right side attended by ischium varum.

The case of Fig. XX. is the only one of those we represent, that presents reflex-stiffness and a proximation (i.e., flexion-adduction-inward ro-

tation) contracture (of the right hip). It is well known that in the proximation contracture of coxalgia the os ischii may also appear bent backward and inward, so in the x-ray plate the whole of the foramen obturatum may disappear behind the os pubis. This bending of the ischium is probably caused by functional stresses. As is well known, the pelvis, in flexion contractures of the hip, shows increased tilting during walking. The functional stresses, therefore, are not transmitted directly to the sacro-iliac joint, but rather to the ischial spine, so that a couple of forces comes into action, which rotates the ischium upward and inward. In the deformation of ischium and pubis in coxalgia we, therefore, meet with a new example of the plasticity of bone through abnormal pressure.

The possibility is not excluded that in the patient of Fig. XX. the spasm and the proximation contracture of the hip is the cause of ischium varum. However, the x-ray so fully coincides with all other cases in which there is no spasm or contracture whatever, that it cannot alter our views.

The characteristic irregularity of the growth-disc is very marked in Fig. XX. In both figures the head shows a shortage of lime-salts.

In both figures the socket-line obviously departs from the head in its lower portion, so the widened socket appears to exist before coxa plana has developed completely. Thus *ischium varum, as the too thick socket-floor, appears to be a primary factor in the development of coxa plana.*

Ischium varum not infrequently coincides with a too thick socket-floor in the same hip. This cannot arouse wonder if their common cause be considered.

Fig. XXII., boy, about 9 years, and Fig. XXIII., V. K., girl, 8 years, are examples of such coincidence. In Fig. XXII., on the right side ischium varum is more conspicuous than the too thick socket-floor; on the left side, on the contrary, the too thick socket-floor is more conspicuous. The effect is practically the same for either: both socket-lines show a widened curve, are too much stretched, and in their lower portion wider apart from the femoral head than in their upper. Consequently the head is flattened in both hips. Both heads, moreover, show fragmentation. And it should be noted that the latter corresponds to the site of the curve in the growth-disc.

In Fig. XXIII., in which the too thick socket-floor is more conspicuous than the varus-position of the ischium, the widened head laterally projects far beyond the bony socket, as in Fig. XI. A latero-position or sub-luxation exists, the inevitable consequence of a too thick socket-floor.

The above examples chosen from our own observations may suffice. In all our other cases of coxa plana as well as in those of the literature which represent both hips, we found the socket-line too much stretched—either through ischium varum or a too thick socket-floor. We have never met with coxa plana in a normal socket. This proves the intimate

relationship between flattened socket and flattened head and has led us to assume that *flattened hip-socket—either through a too thick socket-floor or through ischium varum—is the cause of coxa plana.* And this assumption was confirmed, when it appeared that the effect of the

stresses evoked by flattened socket in femoral head and neck (the couple, the shearing stresses, and the concentrated vertical stresses) perfectly corresponds to what the rules for the growth, formation and deformation of bone with regard to mechanical stresses, which have been established by the study of other skeletal parts, lead us to expect.

In the above we mentioned that flattened socket does not have the same effect on every femoral neck. Three factors here play a role:

(a) *The direction of the femoral neck;*
(b) *The degree of enfeeblement of the individual;*
(c) *The degree of flattening of the socket;*
(d) *Effect of the direction of the femoral neck.*

If the neck is nearer the vertical position than normally, i.e., in coxa valga, the flattening effect of flattened socket is smaller. If, on the contrary, the femoral neck approaches the horizontal position, i.e., in coxa vara, the effect of flattened socket is far more serious than normally.

The following figures may illustrate this:

Fig. XXIV., may represent a normal femoral neck, Fig. XXV. coxa valga, Fig. XXVI. coxa vara. B may be the turning point of the head. If B is supposed to be a fixed point, and perpendicularly above the centre of the femoral head, in all three the couple of forces which we have designated in the previous pages, $=$ AP $\times$BC; BC $=$ BO cos $\angle$ CBO; and $\angle$ CBO $=$ the angle which AP makes with the horizontal line.

So in all three the couple of forces is proportional to the cosinus of the angle which the femoral neck makes with the horizontal. Hence, the direction of AP being vertical, the cosinus of the angle being $=$ o, the couple of forces will be reduced to naught; the direction of AP being horizontal, the couple will reach a maximum. And although the mechanical conditions in the real acetabulum will never fully meet the above suppositions, yet it may be assumed that *caeteris paribus, the action of the couple of forces which we have made responsible for the rotation of the femoral head is smaller than normal in coxa valga; greater in coxa vara.*

The effect of the *horizontal component* of BR (Cf also Fig. IX.) is also proportional to the cosinus of the angle which BR makes with the horizontal. Thus with regard to *the shearing stresses* which we have learned to make responsible for the lateral displacement of the femoral head, the same rule holds good, viz., that *caeteris paribus, they are smaller than normal in coxa valga; greater in coxa vara.*

For the *vertical forces* finally which throng through the point of contact B in case of flattened socket, *the mechanical conditions in the femoral neck to resist them are most favorable in coxa valga, most unfavorable*

in coxa vara. It should be remembered that the convex-sided elements (b Fig. XXVII.) normally transmit pressure stresses by which they are preserved and stimulated to bone-formation. In our study "On Boneformation" we have tried to show that *functional pressure* is a stimulus for bone-formation, whereas tension stresses lack the power of promoting bone-formation.

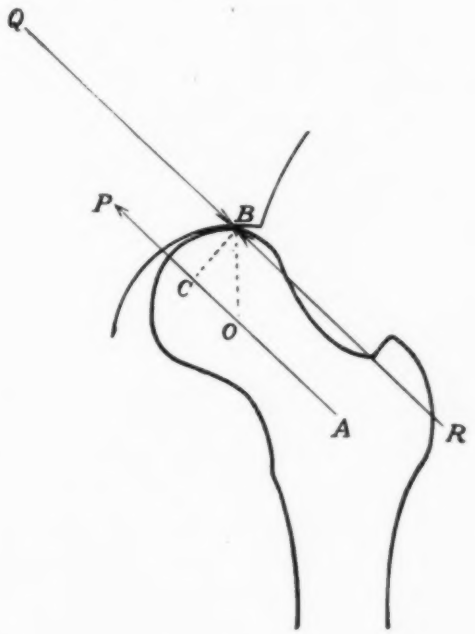


FIG. XXIV
Normal femoral neck and flattened socket. The couple AP×BC is, as in coxa valga and in coxa vara ∴ cos LCBO, hence also ∴ cos of angle at which AP is to horizontal.

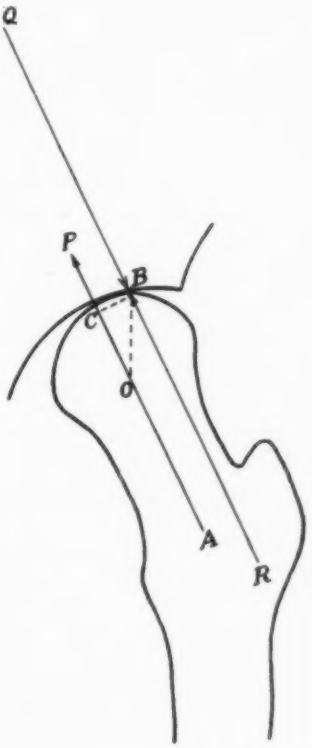


FIG. XXV
Coxa valga and flattened socket. In coxa valga the couple of the acting forces is smaller than normally. The horizontal component of BR, *i. e.*, the one that evokes shearing stresses, is also smaller than normally. Primary coxa valga offers a certain protection from coxa plana.

Note that in the above figures the hip-socket is flattened. Now in the normal neck of Fig. XXVII. the convex-sided bone elements b appear to be practically excluded from transmitting pressure stresses to the

pelvis, since their ends are not in contact with the socket. And the fact that the pressure has to be borne almost exclusively by the concave-sided elements, is the chief cause of their plasticity through excessive weight-bearing. This also holds good for coxa vara (Cf. Fig. XXIX.). In this the convex-sided elements are made to bear tension stresses, which, as has

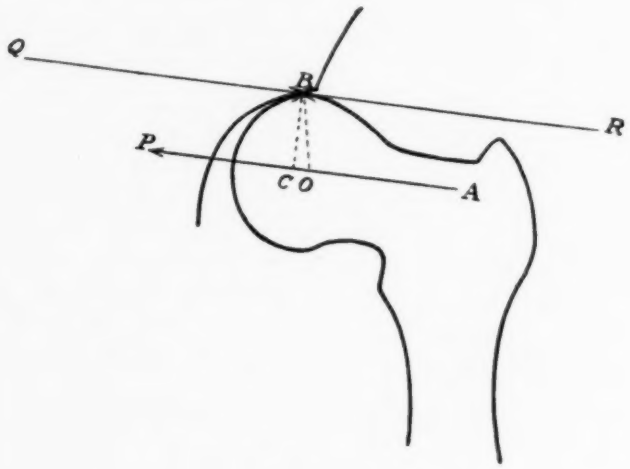


FIG. XXVI

Coxa vara and flattened socket.

In coxa vara both couple and shearing stresses exceed the normal. Primary coxa vara, therefore, enhances the chance of deformation of femoral head and neck in case of flattened socket.

been said in the above, lack the power of stimulating bone-formation. These elements, therefore, are bound to atrophy and possibly to be lengthened or fractured. In coxa valga, on the contrary (Cf. Fig. XXVIII.) the convex-sided elements (*b*) assist the concave-sided elements (*a*) in transmitting the vertical stresses to the femoral shaft and reversely.

Hence it is not doubtful that the deforming effect of the stresses evoked in the femoral head by flattened socket is less than normal in coxa valga; greater in coxa vara.

In flattened socket (a primary) coxa valga offers a certain protection from rotation and displacement of the femoral head, from flattening and widening of head and neck, in short, from the development of coxa plana.

Flattened socket on the contrary threatens (a primary) coxa vara with increased deformation, viz., bending, eventually fracture of the femoral neck.

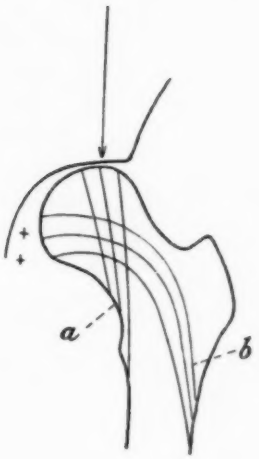


FIG. XXVII

Normal femoral neck and flattened hip socket. The convex-sided bone elements (b) transmit no pressure excesses to the hip socket.

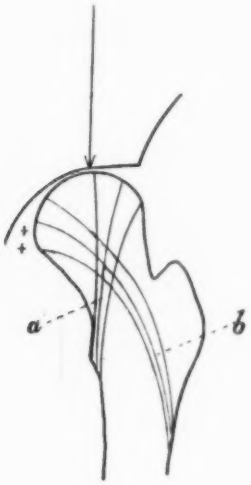


FIG. XXVIII

Coxa valga and flattened hip socket. The convex-sided bone-elements (b) assist the concave-sided (A) sooner than normally in bearing the pressure stresses. Coxa valga therefore offers some protection from deformation of head and neck also with regard to the vertical stresses.

Within the limits of the normal the angle between the femoral neck and the shaft is said to vary 5-10°. Moreover, the amniotic sac which, when remaining too small, levers the femoral head out of its socket, also brings about changes in the position of the femoral neck. Inasmuch as the levering forces are at right angles to the plane of the axis of femoral neck and shaft, they are able only to produce the well known anteversion of the neck. Inasmuch, however, as they act at oblique angles to this plane, they are able, moreover, to modify the angle made by neck and shaft. It, therefore, may be assumed that in the same individual the angle between femoral neck and diaphysis may differ on both sides, especially in congenital dislocation and in flattened socket.

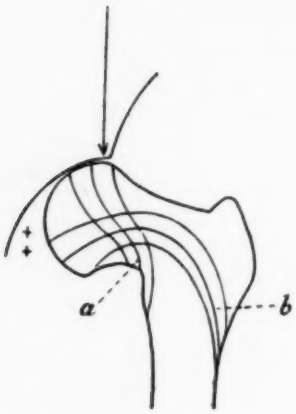


FIG. XXIX
Coxa vara and flattened hip socket.
The convex-sided bone-elements (b) do not assist the concave-sided (A) in bearing the pressure stresses. They are submitted to greater tension stresses than normally. These are no trophic stimulus for bone formation. Coxa valga enhances the chance of deformation of femoral head and neck also by the vertical stresses.

These few degrees of difference may, according to the above, have a share in determining whether flattened socket will cause coxa valga, coxa plana, or coxa vara.

(c) *Effect of the degree of enfeeblement of the individual.*

In the beginning of this paper we have tried to show that the development of coxa plana implies the existence of a place of lessened resistance in the femoral neck near the growth-disc. If that area should be mechanically equivalent to the surrounding parts—as may be deemed probable in unenfeebled individuals—flattened socket would tend to

place the normal femoral head in a valgus position. The less enfeebled the individual, therefore, the more flattened socket will tend to develop coxa valga. The more enfeebled the individual, the less is the resistance near the growth-disc in the femoral neck, i.e., the greater the tendency to develop coxa plana.

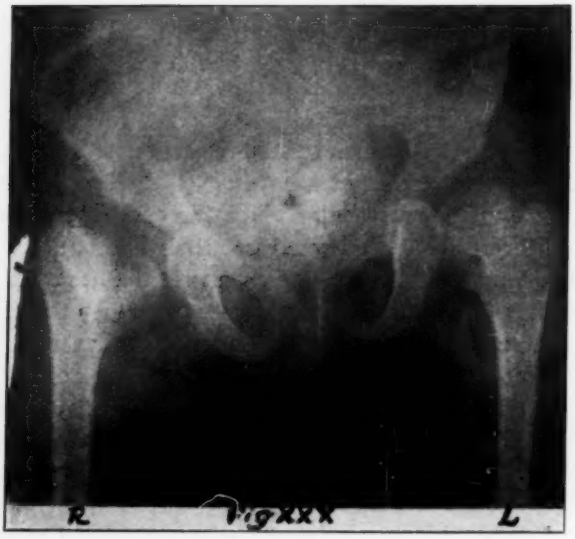
It is well known that in the normal hip-socket, enfeeblement of the individual enhances the chance of a bending of the femoral neck, i.e., of the development of the coxa vara. Hence the enfeeblement of an individual (through injurious agents, whatever their nature), during growth enhances in two ways the chance of progressive deformation of femoral head and neck in case of flattened socket, i.e., strongly tends to produce coxa plana, coxa vara, and even fracture of the femoral neck.

But there is more: It is well known that in the normal hip-socket enfeeblement of the individual enhances the chance of a bending of the femoral neck, i.e., of the development of coxa vara. Hence the enfeeblement of an individual (through injurious agents, whatever their nature), during growth enhances in two ways the chance of progressive deformation of femoral head and neck in case of flattened socket, i.e., strongly tends to produce coxa plana, coxa vara, and even fracture of the femoral neck.

(c) *Effect of the degree of flattening of the hip-socket.*

For completeness' sake it should be observed that in cases of slight flattening of the hip-socket the gap (on the mesial side) between head and socket may soon be filled up, and thus the action of the couple of forces as well as the shearing stresses be overcome. The socket then fits round the head, and all elements in femoral head and neck get their share in bearing the stresses of function; and every reason for the socket to deform femoral head bone and neck is lacking. Slight flattening of the hip-socket, therefore, *ceteris paribus*, leads to slight flattening of femoral head and neck.

It is obvious that internal factors, apart from external ones (traumata), may determine that in one patient two of the three conditions in question occur as may be illustrated by the following figures. And if we call coxa valga, coxa plana, and coxa vara juvenilis (fracture of the neck) 0, 1, and 2 successively after the degree of enfeeblement which furnishes the best chances for their respective development, it may be anticipated that 0 and 1, or 1 and 2 will meet more frequently than 0 and 2. But, be this as it may, *certain it is that the frequent coincidence of coxa valga, plana, and vara in various cases of flattened socket, pleads in favor of their mutual relationship.*



The coincidence of coxa plana on one side and fracture of the femoral neck on the other in flattened socket is shown by Fig. XXX, B., girl, 8 years, with serious enfeeblement of the power of growth (''rickets''). Her father has congenital dislocation of hip On both sides the socket-floor is too thick; the right side, moreover, presents ischium varum. So on both sides the socket-line is partly straightened out, which is enhanced by the sloping direction of the socket-roof. On the left side a characteristic coxa plana has developed in latero-position. On the right side, where the coincidence of ischium varum and a too thick socket-floor causes the ischio-pubic part of the socket to depart still more from the head than on the left side, the downward stresses from the iliac part of the socket have simply displaced downward the head and part of the neck, and broken the femoral neck without any trauma having occurred. This case is not unique. We have observed flattened socket coinciding with severe coxa vara in other patients. That in this case fracture of the neck, or severe coxa vara, has developed on the right side and coxa plana on the left may be due:

1° to the fact that on the right side the socket is more flattened,

2° to the fact that the primary position of the femoral neck approached the varus position more on the right side than on the left; and

3° to external causes, although no abnormal strain can be traced.

Needless to say, the enfeeblement of the power of growth can never account for any difference on the two sides, since feebleness of growth is symmetrical.

The coincidence of coxa valga and coxa plana completa in the same subject is shown in Fig. XXXI., girl, 15 years. The left side presents coxa valga in latero-position with a too thick socket-floor. The socket-line is far more straightened on the left side than on the right, so there the couple of forces and the shearing stresses have been stronger than on the right side, which may account for the development of coxa plana on that side. The head of the coxa valga is flattened, so the mesial border of the neck is higher than the upper border of the foramen obturatum. The neck is a little wider near the growth-disc than in the middle. It is doubtful whether it is widened out. There is no displacement of the head.

Fig. XXXII., S., boy, 14 years, with congenital rigidity, shows ischium varum on the right side, a too thick socket-floor on the left. There is coxa valga on both sides, on the left dislocated a short time before the x-ray was taken. On both sides there is flattening of the head; neck and growth-disc are widened out a little.

Fig. XXXIII., Th., man, 21 years, presents coxa valga with ischium varum on the right side. The slight flattening of the head causes the

R
Fig XXXII
L

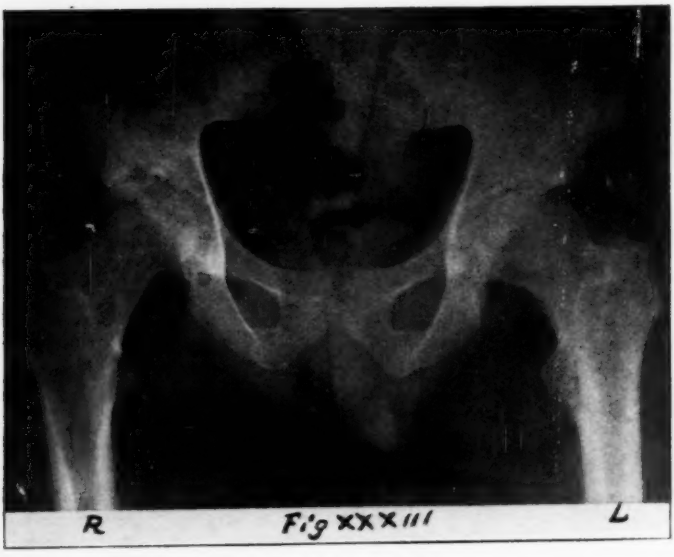

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Fig XXXIII
L

mesial border of the neck to stand too high, but there is no shortening of the neck. The left arm of this man is dwarfed and moreover shows dwarf fingers. Elsewhere we have brought forward reasons for the assumption that too small an amniotic sac may compress flexible parts of the embryo, squeeze the blood out of them, and thus cause local dwarfing, while other parts of the embryo continue their development undisturbed. We, therefore, imagine that the dwarfed arm and the ischium varum have a common cause in too small an amnion. There is pain and crepitus in the joint; but perfect health and no reflex-stiffness. The socket-roof presents irregular decalcified spots at the site of contact with the head (the response of the socket to the concentrated pressure of function: decalcification and plasticity of bone) just above the articular cartilage. In the socket-roof of coxa plana and coxa vara the same phenomenon may present itself. The light spots are observed more laterally, nearer the socket-border, in cases where the neck approaches the varus position.

The previous pages lead to the assumption that flattened hip-socket—either through a too thick socket-floor or through ischium varum—may caeteris paribus cause coxa valga in unenfeebled subjects, coxa plana in the slightly enfeebled, coxa vara and fracture of the neck in those who have been seriously enfeebled by injurious agents, and that where two of these conditions meet in the same individual, a primary difference in the position of the femoral neck or in the form of the socket, as well as external causes (traumata), may be responsible.

The following may give a short account of the consequences of flattened hip-socket, as described in the above study.

A, in subjects with slight enfeeblement (of the power of growth),
B, in unenfeebled subjects,
C, in subjects with severe enfeeblement (of the power of growth).

In doing so we will consider a hip-socket with serious flattening in which early co-aptation of the joint-surfaces is impossible, and thus the deformation of the head may be complete.

> Enfeeblement of the power of growth is brought about by injurious agents which act on a child, either before or after birth, or on the germ cells from which it develops. In cases of slight enfeeblement only the parts growing most rapidly sustain enfeeblement of their power of growth, in more severe cases in succession also the parts which grow less rapidly.

In *slight feebleness of growth* it is only the power of growth of the muscles, which constitute 43% of the body-weight in the normal adult, and thus normally claim about as much of the power of growth which is enfeebled: there are flat feet, prominent abdomen, round back and acrocyanosis.

In *moderate feebleness of growth* signs of enfeeblement become, moreover, manifest in the skeleton, which constitutes 17% of the normal body-weight. This again is first observed in the skeletal parts which grow most rapidly, viz., in the growth-discs near the knee. They show decrease of growth to increase of pressure—the outcome of enhanced fatigability, which in its turn is associated with enhanced irritability.

In *severe feebleness of growth, moreover,* all other growth-discs show enhanced fatigability. There is retardation of growth and extra-retardation of differentiation.

For further information cf. "Feebleness of Growth and Congenital Dwarfism."

A. The consequences of flattened hip-socket in subjects with slight feebleness of growth.

Imagine a child in whom the flattened hip-socket is associated with feebleness of the musculature and slight genua valga or none at all. The couple of forces and the vertical component of acting forces (Cf. Figs. VIII. and IX.) cause increase of pressure to the lateral parts of the growth-disc in the femoral neck, decrease in the mesial part. This leads to a difference of growth between the medial and the lateral parts of the growth-disc, agreeing with what occurs in the growth-discs near the knee during the development of knock-knee. In the femoral neck this difference of growth becomes manifest in the rotation of the growth-disc to the horizontal. This rotation is slow and may take up years, as well as, for instance, the development of knock-knees.

As the growth-disc approaches the horizontal, the action of the shearing stresses may become patent; the chance of lateral displacement and hence of vascular lesions which also have been brought about during the development of the angular irregularities becomes greater. Traumatized areas in the bone in the vicinity of the growth-disc start reparative processes—comparable to those in bone fractures—associated with resorption of limesalts and callus-formation. (Decalcified spots in femoral head and neck). Enhanced plasticity ensues. If weight-bearing is

obviated, a chance of renewed firmness of the bone is opened. The continuation of weight-bearing, however, during the reparative process is comparable to early weight-bearing in case of fracture: it maintains plasticity. This starts in the vicinity of the growth-disc and spreads from there, which becomes manifest in the pear-shape of the femoral neck. The vascular lesions near the growth disc thus are probably the *conditio sine qua non* for the very considerable flattening of head and neck. If the shearing stresses last, a vicious circle is set going. The supposition seems justified that reflex stiffness develops, when the vascular lesions and their consequences surpass certain limits (*coxa plana contracta*).

As the femoral head and neck widen out, the area of contact with the socket enlarges. The action of the couple of forces then diminishes and the rotation of the growth-disc comes to a standstill. The plasticity, however, once brought about, remains on account of the continuation of weight-bearing; progressive thinning and widening of the head and shortening and broadening of the neck presents itself. From the pear-shape of head and neck it may be concluded that in the head and upper part of the neck the plasticity is greatest. The fragmentation of the head is the manifestation of an insufficiency of plasticity with regard to the demands.

Re-union of the parts and, in the adult, the disappearance of the growth-disc follow. The presence of considerable flattening, shortening, and widening of head and neck in advanced years bear testimony to the early development of these changes. (Cf. B).

If even in advanced years the area of contact between head and socket is smaller than normally, the deformation may continue and is more and more identical with the way to be described under B.

B. Consequences of flattened hip-socket in unenfeebled subjects.

In the rotation of the growth-disc the area of the femoral neck in its vicinity mechanically behaves as an area of lessened resistance such as cannot be assumed to exist in normal bone substance. In proportion as the subject is less enfeebled, is nearer the normal condition, the couple of forces tends more to raise the whole of the femoral neck into a valgus position. During this rotation of the femoral neck the couple of forces becomes smaller and smaller as well as the action of the shearing forces (Cf. Figs. XXIV and XXV) and with it the chance of vascular lesions and plasticity through reparative processes. The causes of flattening, shortening, and widening of the neck thus exhaust themselves in the erection of the femoral neck.

During the erection of the femoral neck the bone elements on the convex side participate more and more in bearing the vertical stresses which throng into the head through the small area of contact with the socket. Thus the danger of excessive weight-bearing, shortening and widening becomes less.

While in flattened socket coxa valga on the one hand the chances of flattening and widening of head and neck are lessened, on the other hand the incongruence between head and socket is enhanced. Thus in coxa valga the chance of the joint cartilage being worn at the area of contact is larger than normally. Decalcified spots just below the articular cartilages present themselves. They correspond to the highest point of the femoral head and therefore present themselves in coxa valga more mesially than in coxa vara.

In proportion as the bone is firmer, —i.e., as the subject is nearer the normal condition—or also in proportion as these phenomena develop later in life—as in cases of slight incongruence—the deformation of the head is limited to more superficial layers. Hence in more advanced years lipping is observed: plasticity of the upper layers of the femoral head only, "mushroom" formation. The supposition seems justified that, as an attempt at restoration, blood vessels widen out and bring about this lipping, which is characteristic of all excessive weight-bearing in articular surfaces. The condition is known under the name of "osteo-arthritis." "arthritis deformans," or "malum coxae." We call it *"joint-wear," in casu "hip-joint wear."*

C. *Consequences of flattened hip-socket in subjects with severe enfeeblement of the power of growth.*

Imagine a child in whom all growth discs show differences of growth by their oblique position with regard to the diaphyses, and a curving of the latter. Suppose there is slight symmetrical coxa vara and flattened hip-socket only on one side.

The growth disc is, by the couple of forces, relatively easily made to approach the horizontal. From a mechanical point of view the vicinity here offers less resistance than in slightly enfeebled and unenfeebled subjects. This implies that, in proportion as the enfeeblement of the power of growth is more intensive, the femoral neck itself is less affected by the erecting power of the couple of forces evoked by the flattened hip-socket.

The convex sided elements in the femoral neck are more curved than normally. Therefore the moment of the vertical component of the act-

ing forces which tends to bend these elements, is *ceteris paribus* greater than normal. These convex-sided elements, moreover, lack more of the trophic stimulus of function in proportion as the varus position is more developed: their mesial end is less in contact with the socket floor and can therefore transmit less pressure to it. In other words, in coxa vara there is more reason for their atrophy than normally.

Flattened hip-socket in severe feebleness of growth thus enhances the chances of further bending, and even of fracture of the femoral neck.

It thus appears that seemingly dissimilar and even contrasting conditions—coxa plana, valga, vara, (fracture of the femoral neck) malum coxae—may have a common cause in flattened hip-socket, i.e., ischium varum or thick socket-floor.

It stands to reason that differences in the primary position of the femoral neck, differences in the form of flattened socket—as for instance wry socket or sloping socket roof—transitions between the degrees of feebleness of growth described, differences in the amount of rest and weight-bearing, and possibly a complication with infection, may in each special case of flattened hip-socket render it difficult to recognize the developmental forms just sketched.

In conclusion, we will compare the hypotheses hitherto brought forward concerning the cause of coxa plana with the theory of the previous pages. They are mainly: "rachitis," traumata, infection, congenital abnormalities of the femoral head. The first three are based on facts observed in conjunction with coxa plana. The last one is not. Nor does it explain any of the phenomena, but obscures them by the addition of more obscurity.

"*Rachitis*" (severe feebleness of growth), be it in its less severe form, has in the above proved to be a promotive agent of the development of coxa plana.

Of *traumata*, vascular lesions have indeed seemed apt to occur as a result of the rotation and displacement of the head. Of external forces, it must be admitted that they may promote fragmentation as well as flattening and widening of femoral head and neck.

Infections in other parts of the body may act as an injurious agent and cause enfeeblement which leads to the development of coxa plana, while on the other hand bacteria doubtless find a prepared soil in the femoral head and neck themselves, especially during the fragmentation stage, inasmuch as circulation and nutrition have been injured in broken up parts.

Calot and the author have, moreover, expressed the opinion that coxa plana should be due to a congenital subluxation of the hip (a too thick socket-floor). The addition of the ischium varum (i.e., the widened socket) in the present paper may be considered a completion of this notion.

The theory of the previous pages thus encompasses the professed hypotheses. It takes into account the facts on which they are based and points out the position they occupy in the development of this hitherto obscure condition. But, moreover, it makes us understand why so very few people who show signs of feebleness of growth are affected by coxa plana, and, if so, often on one side only, in this so exceptionally symmetrical condition; why serious traumata may act with impunity on the great majority of children, while in those under discussion a slight trauma may call forth or increase the phenomena; and finally why most of these conditions develop without the slightest signs of infection, while only a small percentage with reflex-stiffness around the hip raises suspicion of a bacterial focus or develops a culture upon bacteriological examination.

And the answer to these various "why's" seems to have been brought chiefly by 1° the two phenomena, *ischium varum* and the *too thick socket-floor*, which produce the widened and flattened acetabulum; and 2° by rules of bone growth,—formation and deformation in relation to mechanical stresses.

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MEASUREMENT OF THE RANGE OF MOTION IN JOINTS.*

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MEASUREMENT of the range of motion in a joint is of value as a means of control in treatment and of record in military and medico-legal work. Considerable uncertainty seems to exist as to the proper point from which the degree of motion is to be estimated, and there does not appear to be any agreement as to the best and most accurate method of measurement. The following method is therefore suggested, as simple, easy of execution, and sufficiently accurate.

Protractor. A protractor of the simplest kind, with a long arm, is necessary. At the proper place in the centre of this arm is a heart-shaped opening through which the scale is read. A stand is provided with a hinged upright, to which the protractor is attached, in such a manner that it can be moved upward and downward in the vertical plane or folded so as to lie in the horizontal plane. This adjustment is arranged so that the protractor may be used in either the vertical or the horizontal positions and so that the center of its arc corresponds with the center of the joint measured.

Requirements as to Position. For accurate measurement, one segment of the joint which is to be measured and the base of the protractor should be firmly fixed in the same plane. This is ordinarily most easily accomplished by resting the entire upper segment of the joint on a table, the patient being in the recumbent position; the protractor is then placed beside it and the center of its arc raised until it coincides with the center of the joint.

The mensuration of the degrees of motion in joints must start from a zero plane. The zero plane in measuring joint motion shall be considered to be an extension of the plane of the long bone or bones immediately proximal to the joint in question.

In the hip and the shoulder, the lateral and the antero-posterior planes of the trunk shall be considered the planes of zero. In the spine, the degrees of motion shall be measured from the zero of the centre of gravity of the body.

*This method of the mensuration of joints was devised during the war, but, though approved for publication by the Surgeon-General on May 16, 1919, was never published. It is presented now in the hope that it may aid in the establishment of a standard.

Acknowledgment is made of the valuable assistance given by Dr. R. B. Maddox in the designing of the protractor, and also of the helpful criticism of Drs. Kendall Emerson, Robert B. Osgood, and R. Tunstall Taylor.

SHOULDER JOINT.

Abduction. Position: patient lying on back with body straight and arms at side; protractor folded on its stand and laid on the shoulder so that its base coincides with side line of body and the center of its arc with center of joint; indicator points toward hand and registers zero. A finger should be kept on the scapula to note when it begins to move. In this position abduction is normally 90 degrees without movement of the scapula.

Forward Elevation. Position as above; inner surface of protractor is placed against outer surface of shoulder and the center of its arc raised to coincide with center of shoulder; indicator points toward hand and registers zero. In this position forward elevation is normally about 110 degrees.

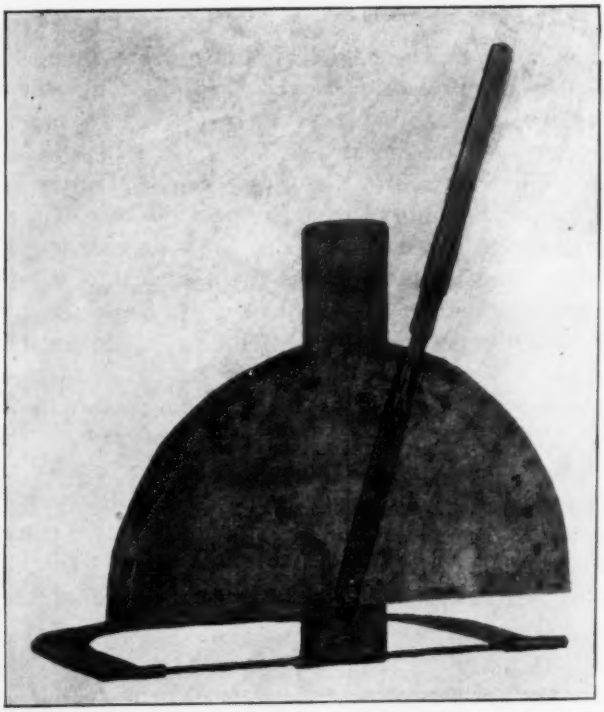

FIG. 1.

The original protractor, reduced to about one-third actual size, seen from the front. The protractor itself is shown partly raised on the hinged upright of the stand. The indicator, which is provided with a sliding extension, is shown closed.

Rotation. Position: Patient lying on back; arm abducted at right angles from body at shoulder; forearm flexed to right angle at elbow and held perpendicular; inner surface of protractor is placed against outer surface of elbow. Scale is read from 90 degrees, considered as zero. In this position outward and inward rotation are practically about 90 degrees.

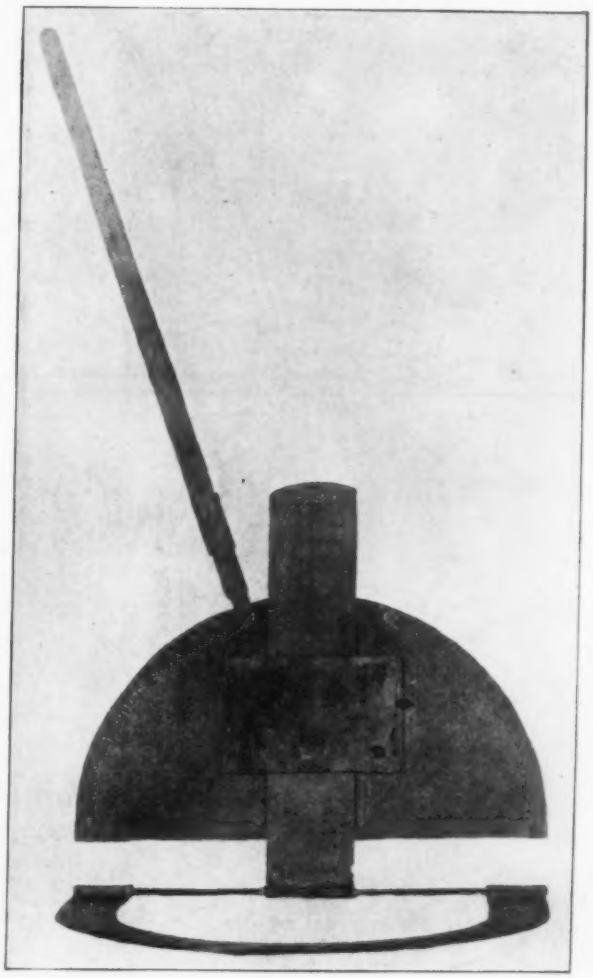

FIG. 2.
The original protractor, seen from the back. The indicator is shown opened.

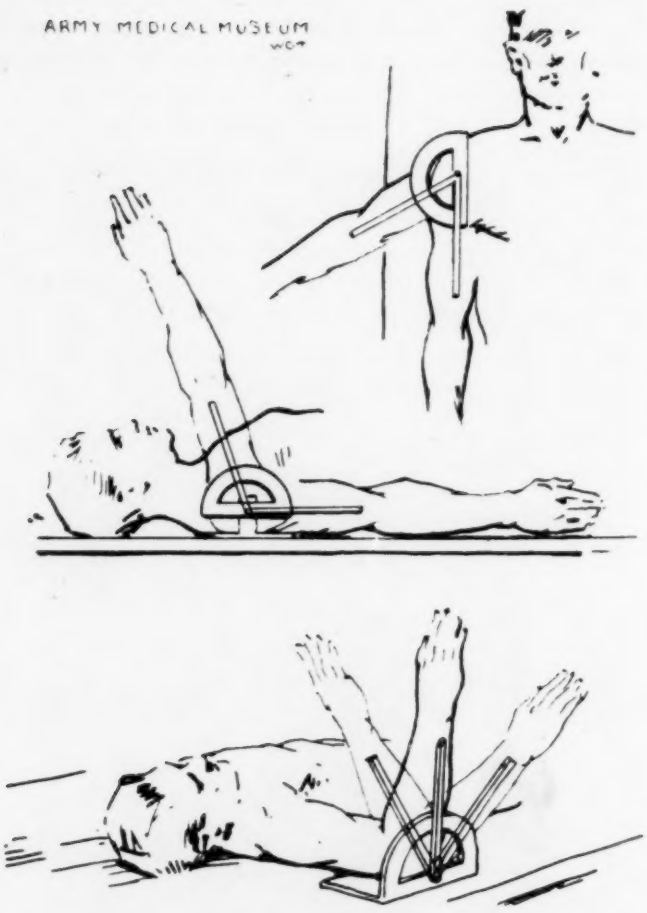

FIG. 3.
Upper: Position in measuring abduction of the shoulder.
Middle: Position in measuring forward elevation of the shoulder.
Lower: Position in measuring rotation of the shoulder.

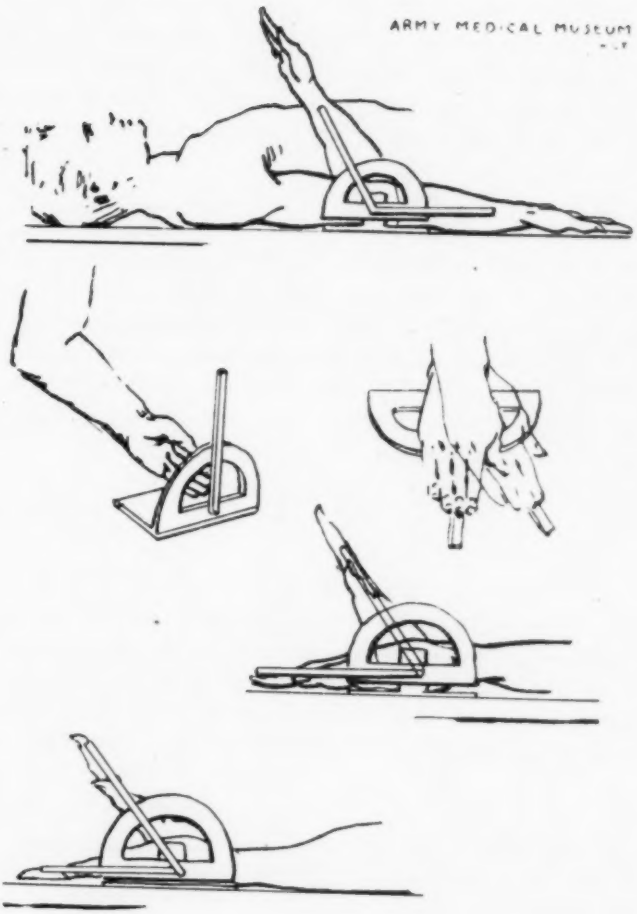

FIG. 4.

Upper: Position in measuring flexion and extension of the elbow.
Middle (Left): Position in measuring rotation in the radio-ulnar articulation (pro- and supination).
Middle (Right): Position in measuring ab- and adduction at the wrist.
Lower: Position in measuring flexion and extension at the wrist.

ELBOW JOINT.

Flexion and Extension. Position: patient lying on back with arm extended at side and palm upward; inner surface of protractor is placed against outer condyle of humerus and the center of its arc raised to coincide with center of elbow joint; indicator points toward hand. Full extension is indicated by 0 degrees and full flexion is normally about 140 degrees.

Rotation in Radio-ulnar Articulation (Pro- and Supination). Position: patient lying on back with hand resting on ulnar border and thumb pointing upward, or sitting with elbow flexed to a right angle and resting on a low table; inner surface of protractor is placed against ends of fingers at right angles to long axis of arm, so that the center of its arc coincides with end of little finger. The scale is read from 90 degrees, considered as zero. Measured in this way, pronation and supination are each normally nearly 80 degrees.

HAND.

Flexion and Extension. Position: patient sitting, with forearm resting on a low table, or lying on back with arms extended at sides. Palm is turned upward in testing flexion, and downward in testing extension; inner surface of protractor is placed against outside of wrist and the center of its arc raised to coincide with center of joint; indicator points towards fingers. Flexion and extension are each normally about 70 degrees.

Abduction and Adduction. Position: patient lying on back with arms at sides and hands fully pronated. Fold protractor and place it under arm so that its base is opposite wrist joint and at right angles to long axis of arm, and so that the 90 degree point is opposite the middle finger. In this position, abduction and adduction are each normally about 35 degrees.

FINGERS.

Flexion and extension may be measured with this same instrument, the back of the proximal joint resting on the table; but it will be found more convenient to use instead, the special finger protractor devised at Hart House, Toronto (see McKenzie: Reclaiming the Maimed, p. 68).

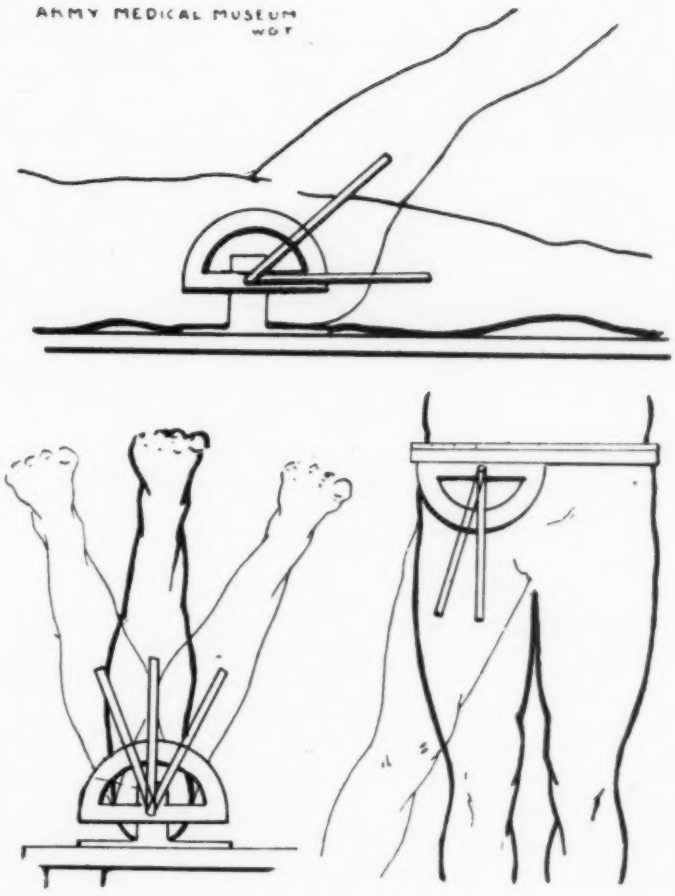

FIG. 5.
Upper: Position in measuring flexion of the hip.
Lower (Left): Position in measuring rotation of the hip.
Lower (Right): Position in measuring ab- and adduction of the hip.

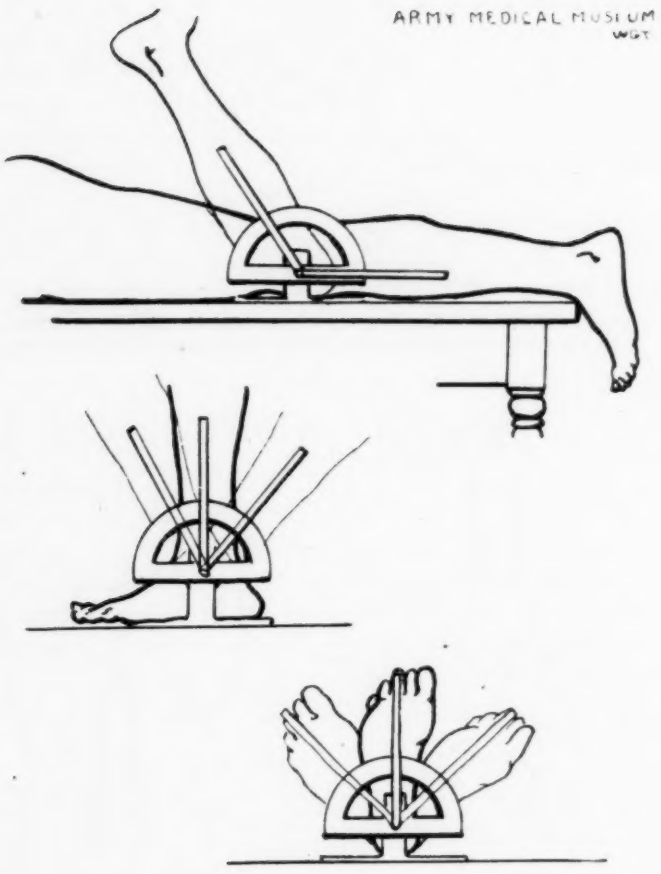

FIG. 6.
Upper: Position in measuring flexion and extension of the knee.
Middle: Position in measuring flexion and extension at the ankle.
Lower: Position in measuring ab- and adduction of the foot.

HIP.

Flexion and Extension. Position: patient lying on back, with toes pointing directly upward; inner surface of protractor resting against outer surface of hip, with center of arc opposite center of trochanter and indicator pointing toward center of outer condyle; assistant flexes opposite hip to disclose concealed flexion. Normal range of motion is from 0 degrees in full extension to about 130 degrees in full flexion.

Abduction and Adduction. Position: patient as before; protractor is folded; a ruler is so placed that its edge is pressed closely against the lower surfaces of the two anterior spinous processes and the protractor is laid on the hip so that its base rests against the ruler and the center of its arc lies over center of hip-joint. With the leg in the middle position (the toes pointing directly upward) the indicator will point to 90 degrees. Abduction and adduction are each normally about 45 degrees.

Rotation. Position: patient lying on face with knee flexed to a right angle; place protractor so that it rests against the anterior surface of the lower leg at right angles to the long axis of the thigh. The scale is read each way from 90 degrees, considered as zero. Outward and inward rotation are each normally about 45 degrees.

Hyperextension. This may be estimated in a similar manner to flexion and extension but with the patient lying on the face. It is normally about 10-15 degrees.

KNEE.

Flexion and Extension. Position: patient lying on face, with inner surface of protractor resting against outer surface of knee and center of its arc raised to coincide with center of knee joint. Full extension is indicated by 0 degrees and full flexion is normally about 130 degrees.

FOOT.

Flexion and Extension. Position: patient standing; inner surface of protractor rests against outer surface of ankle, center of arc being raised to coincide with center of ankle. Patient bends backward for planter flexion and forward, keeping the knee straight, for dorsal flexion. The scale is read from the middle position (90 degrees). Plantar flexion is normally about 60 degrees, and dorsal flexion about 20 degrees.

These measurements may be taken in a similar manner with the patient lying, by placing a board against the foot on which the protractor is then rested.

Abduction and Adduction. Position: patient lying; inner surface of protractor placed against sole of foot with the 90 degree point, considered as zero, opposite the middle toe. The leg must be held firmly to prevent it from rotating. Abduction is normally 10 and adduction 30 degrees.

THE RELATION OF LESIONS OF THE TRANSVERSE PROCESSES TO PAIN IN THE BACK AND LEGS

BY GEORGE I. BAUMAN, M.D., CLEVELAND, OHIO

In cases of lumbo-sacral pain and in cases with pain referred down the leg, whether with or without definite history of injury, the possibility of anomalies of or injury to transvere processes should be given careful consideration in differential diagnosis. Routine x-ray examinations and dissections of the lumbar spine reveal wide variation in the length, shape, and direction of the transverse processes. These variations are not limited to any one segment of the spine, although the fifth lumbar process is the most frequent site of congenital abnormality.

The nerve cords of portions of the lumbo-sacral plexus and some of their branches lie in close proximity and directly anterior to the transverse processes of the last four lumbar vertebrae. Any slight change in position of one or more of these processes, due either to fracture or to slight rotation of the vertebral body can result in direct pressure by the process upon the underlying portions of the plexus. The irritation of these nerve cords or branches may be responsible for numerous neurological symptoms in their field of distribution. It may be evidenced by pain, numbness, atrophy, paresis or paralysis, in certain areas of distribution of these nerves. The etiology of a number of obscure cases of lumbo-sacral neuritis, the majority resembling sciatica, has been explained upon this intimate anatomical relationship.

Attention has been called by Richard (1) to the incidence of lumbo-sacral pain and referred pain, associated with congenital malformation of the transverse process of the fifth lumbar. He concludes that the referred pain is due to (a) compression of soft tissues, (b) irritation and arthritis of abnormal joints and bursae, (c) slow acting strain on the ligaments or (d) to pressure or tension of the segments of trunks of nerves. Lavieri (2) refers to elongation of the fifth process as a cause of backache. Moore (3) has recently published a series of cases in which such a group of symptoms was relieved by removal of a portion of the offending fifth process. Davis (4) in 1919 reported a series of ten cases of fracture of the lumbar transverse processes, which were removed with excellent results. He concludes that such fractures are not unusual as a result of indirect violence.

During the past eighteen months there have come under my observation on the orthopaedic services of Lakeside Hospital and Cleveland City Hospital twenty cases which have presented a combination of history, physical findings, and frequently x-ray evidence, indicating some lesion of one or more of the lumbar transverse processes. The duration of symptoms has varied from three weeks to six years. Fifteen of these gave a definite history of sudden injury, in most cases indirect in type. Two additional cases gave a history of possible injury. Two of these complained of pain in the back only. Thirteen complained of pain in both back and groin, buttock, thigh, or leg. Five had referred pain only. Two complained also of numbness, paraesthesias or weakness. The most constant pain on motion was in flexion. Atrophy of muscles of the buttock, thigh, or calf was noted in four instances.

The most constant finding in these cases, and the one to which I have been led to give much significance, is the location of a definite highest point of tenderness to deep pressure over the tip of one of the transverse processes. In a number of instances the patient volunteered the information that he experienced "pain down the leg" in addition to local tenderness, when pressure was made directly over the site of the lesion. Attention should be given to the fact that the tip of an abnormally long offending transverse process may be located at a considerable distance—two to four inches—lateral to the mid line. In some thin individuals abnormally long processes of the first, second, and third lumbar may be palpable. X-ray examination of this group of cases revealed congenital abnormalities, in size or shape, in six instances. Some, however, appeared perfectly normal. One showed partial necrosis. One showed definite fracture of two processes. Operation revealed a third fracture which did not show in an excellent stereoscopic x-ray view.

The history and the physical and x-ray findings have been considered sufficient justification for operative interference in nineteen instances. Resection of one or more transverse processes was performed. In one recent case operation has been advised. Brief summaries of the histories of these patients are given below.

Case 1. S.F. A white laborer, age 41 yrs., complained of pain in back and left hip of two years duration, following an injury. He had been able to do some light work,but was not able to work at his occupation as a carpenter. Pain had been continuous. At times he had been confined to bed, and on admission local signs were so marked that he was sent in as a suspected case of tuberculous spine. Examination showed localized tenderness over the fifth lumbar transverse process on the left.

X-ray showed a greatly elongated fifth process on each side. Transversetomy was performed on the left. Symptoms had disappeared at the time of discharge, and at the end of about six weeks he was able to resume work at his former occupation as a carpenter. Two years later this patient received a severe twist of the back in a street car accident and returned with identical symptoms of the right side. Removal of the abnormal right process has been advised.

Case 2. M.M. A white female, 37 years of age, complained of pain in the back and down the inner and anterior aspect of the right thigh, for a period of two years and nine months. The onset was sudden, when the patient reaching across a bed to lift a heavy mattress, felt a sudden sharp pain in the lower back. Since that time she has been troubled constantly with pain in the back and pain radiating down right leg. Manipulation and plaster corset had given no relief. She entered the hospital on crutches. Examination showed marked tenderness, muscle spasm, and rigidity of the lumbar spine, with a maximum point of tenderness a short distance to the right of the spine of the fourth lumbar vertebra . X-ray showed a slight upward angulation of the transverse process of the fourth lumbar, with indication of an old fracture at its base. Resection of the right transverse process was performed. After removal of the process several small fragments of bone were found adherent to the nerve cord lying directly beneath. These were carefully dissected away. No indication of a line of fracture was, however, found. The patient can now walk considerable distances without any means of support, using a cane only at times. She has much less referred pain than before operation.

Case 3. J.M. White male, age 40 years, complained of pain in the back and radiating to the right hip, six months duration. No history of trauma. He has no pain while at rest in bed, but pain on turning over and when up. Physical examination showed limitation of flexion and hyperextension and muscle spasm on the right. X-ray showed abnormally long transverse processes on the right of the fourth and fifth lumbar. Plaster corset for four weeks gave temporary relief but the pain soon returned, greater in intensity. The fifth right process was removed. At the end of six weeks the patient returned to work. He has had no recurrence of pain in back or hip.

Case 4. C.K. A white male, laborer, gave a history of a sudden severe pain in the left lumbar region and extending down the left leg. This followed a sudden twist when the patient stepped, without warning, into a hole, while he was carrying a heavy packing case. He was unable

to do any kind of work. Examination revealed marked tenderness to pressure over the left fifth lumbar process with accentuation of pain down the leg. X-ray showed a large, irregular left process of the fifth. Operation: resection. Pain has entirely disappeared, and the patient returned to his former work at the end of six weeks.

Case 5. W.L. Patient a white laborer, age 34 years, gave a history of sudden onset of pain in the lower lumbar region and referred down the back of the thigh and outer side of the leg. This began with a sudden sharp pain when he attempted to hold the entire weight of a heavy casting, after the fellow workman helping him had stumbled. X-ray showed very large sacralized transverse processes of the fifth lumbar, with the largest on the left. Manipulation under anaesthesia, followed by plaster spica and recumbency for four weeks, gave no relief. The patient had definite localized tenderness over the left fifth process, accompanied by accentuation of leg pains. Resection was performed. Immediately on removal of the process the nerve trunks lying beneath bulged upward into the space which the process had occupied. Edges of the base were carefully smoothed off. Following the operation the patient had some anaesthesia of the areas supplied by the superficial peroneal nerve. He had no paralysis or paresis. The anaesthesia disappeared after a few days. The patient's symptoms cleared up entirely and he was able to be back at work at the end of six weeks.

Case 6. C.M. Patient suffered severe pain in the lumbar region after being struck by an automobile and hurled to the pavement. There was no external evidence of trauma, but the patient had exquisite tenderness over the transverse processes of the second, third, and fourth lumbar vertebrae on the right. Excellent stereoscopic x-ray plates showed definite fracture of the third and fourth. Operation revealed also a fracture of the second process, which could not be detected on careful reexamination of the plate. Recovery was complete after removal of the three fractured processes. This case is offered as an illustration of multiple fracture of transverse processes as a result, apparently, of indirect violence. It also illustrates the fallacy of depending entirely on x-ray for the diagnosis of fracture in this location.

Case 7. J.A. White male, about 40 years of age. Occupation: policeman. Illness began one and a half years previous to first admission, with pain in the calf of the right leg, which gradually progressed upward into thigh and hip. He had pain in the thigh for eight months, and severe enough to force him to go to bed sx months previous to admis-

sion. He was in the hospital on several occasions. Manipulation under anaesthesia and application of plaster spica cast for four weeks was of temporary benefit. X-rays were negative, but the patient had definite localized pain to pressure over the fifth right process. Resection of this process was performed and after removal there was found a small, firm, fibrous band beneath, pressing upon the nerve trunk. This band was dissected away. Following operation the pain disappeared gradually, and he is now able to be on duty. He experiences only a slight amount of pain on over-exertion.

Case 8. K.M. A white female, age 32 years, complained of pain in the region of the left hip only. She had been confined to bed for seven weeks previous to admission. There is a questionable history of injury. There was some pain to extreme flexion of the hip, but no point of tenderness in the hip region. Posteriorly in the left lumbar region, about three inches to the left of the spinous process of the third lumbar vertebra, was a palpable, bone-like knot, very tender to pressure and movable antero-posteriorly. The pain in the thigh was greatly accentuated by pressure on this transverse process. The third process on the opposite side was easily palpable but not tender. The pain in the thigh and the point of tenderness in the back persisted after two additional weeks rest in bed in the hospital. Repeated x-ray examinations of the sacro-iliac region and hip were negative but both third processes were abnormally long. There was no evidence of fracture. Operation was considered advisable because of the persistence of tenderness of the palpable process and the accentuation of the hip pains. The process was found to be about two inches long and with its distal three-eighths of an inch, attached by a fibrous, flexible connection. This distal portion was freely movable. On removal of the process a lumbar nerve appeared just beneath the distal fragment. The pain in the hip was entirely relieved and the patient now, eight weeks after operation, is able to be about and do her own housework. Note that the movable distal fragment, either an anomaly or an old fracture, was not detected by x-ray examination.

Case 9. S.H. Patient, a white male, 40 years of age, gave a history of pain in the right hip for eight months following a fall. There was no pain on motion of the hip joint. Some atrophy of the muscles of left thigh, buttock, and calf. Pressure over the sciatic nerve caused no pain. Hyperflexion of the thigh, however, caused considerable pain down the leg. There was marked tenderness to deep pressure in the right ilio-vertebral angle which caused the patient to complain of pain

down the leg. Rectal examination was negative. X-ray of the lumbar spine showed some proliferation at the margins of the vertebral bodies. Persistence of the point of tenderness with the accompanying referred pains was considered justification for exploration of the transverse processes of that region. Excision of the fourth and fifth right processes was performed. Patient left the hospital still complaining of some pain. He has since reported, however, that he has no further pain. Slight weakness on walking long distances.

Case 10. E.G. Patient, a white male, about 25 years, entered the hospital complaining of pain in the lumbar region and down the legs. Pain came on suddenly on attempting to lift a heavy weight. There had been a previous operation one and a half years before in the right lumbar region, for the incision of an abscess. The wound was healed, x-ray showed possibly a little absorption of the transverse process of the third lumbar on the right. There was a definite point of tenderness here. The vertebral bodies and intervertebral discs were normal in appearance. A diagnosis of osteomyelitis did not seem justifiable at the time of admission. The patient was operated upon at his own request only after repeated casts, braces, and manipulation over a period of one year had failed to give relief. At the time of exploration there was necrosis of a portion of the transverse process and pus was found. It was considered a case of osteomyelitis and the remains of the process were removed and the wound drained. Sequestra were later removed. A pathological diagnosis of bone tuberculosis was made on examination of the process. Extension occurred to the bodies of the vertebrae and patient has since died of bone tuberculosis. This case is given as a rare and obscure lesion accounting for backache and pain in the legs and also as an unusual location for the primary lesion of bone tuberculosis.

Case 11. R.C. Patient was a colored male laborer, 46 years of age. Following a fall while carrying a heavy load, nine months previous to admission, patient has had pain in the lower lumbar region and right leg. This has been continuous but did not entirely incapacitate him for work until a short time before admission. Examination showed tenderness to pressure over the right fifth transverse process with accompanying pain referred down the right leg. No paralysis or paresis. Transversectomy, right fourth lumbar performed. Patient left hospital in two weeks, his condition much improved. When last heard from he was relieved of symptoms and back at steady work.

Case 12. A.C. Patient, a white male, 33 years of age, entered the hospital complaining of pain in lower part of back and referred to the

buttock and part of the thigh on the right side. There was marked tenderness to pressure over the fifth lumbar transverse process on the right with pain referred down the right thigh. X-ray reported negative. Transversectomy of the right fourth and fifth lumbar performed. Patient left hospital at the end of two weeks with symptoms relieved. He is now back at work.

Case 13. A.C. A white male laborer, 30 years of age, complained of pain in the left hip and leg of two months duration. The onset was sudden, beginning when the patient "strained" himself while lifting a heavy load. Manipulation and plaster cast gave no relief. Patient returned again with the same complaint. There was a definite point of tenderness over the left third and fourth transverse processes. These were resected. Patient later returned, still complaining of pain in the leg. At this time the left fifth process was removed. Since this he has been much improved.

Case 14. H.P. Patient is a white male, 47 years of age, complaining of pain and loss of sensation in the left thigh following a fall down stairs three weeks prior to admission. He had marked tenderness over his left fifth transverse process, and pain in thigh was increased with pressure over the tender spot in his back. X-ray showed some rotation of the fifth lumbar on the sacrum. The left fifth process was removed. The patient is now at work regularly in the coal mines.

Case 15. J.M. A white male, age 34 years, twisted his back when he fell while carrying a 100-lb. keg of nails. Complained of pain in the back and radiating down the back of the left leg to the knee. There was definite tenderness over the fourth and fifth processes on the left, accompanied by accentuation of leg pain. One quarter inch atrophy in circumference of right leg. X-ray showed marked rotation of spine and abnormally long transverse processes of the fifth lumbar impinging on the ilium. The entire fourth and part of the fifth left processes were removed. On discharge at the end of three weeks patient had relief of the pain that caused admission. He had some loss of power of flexion of the toes of the left foot. Lately this has decreased in amount.

Case 16. H.T. Age 53 years. A white male patient, had worked twelve years at a machine where he pressed a pedal with the left foot. One year previous to admission he suddenly noticed pain radiating down the posterior portion of the left thigh and ending in numbness and tingling in the foot. The pain was accentuated when working at the machine and when rising from a sitting posture. He had been compelled

to give up his work. Examination showed definite localized tenderness to pressure over the third, fourth, and fifth lumbar transverse processes on the left, causing pain to radiate down the posterior portion of the left thigh. There was no atrophy. The pre-operative x-ray was reported negative. At operation the fourth lumbar transverse process was removed on the left. The patient complained of slight pain in the region of the operation, but no radiation of pain down the leg, two weeks post-operative.

Case 17. F.S. A white male, age 48 years, was in an automobile accident seven months previous to admission. He suffered a "twisted back" and since has had pain in the back when lifting. Examination showed tenderness over the third, fourth, and fifth lumbar transverse processes, with pain radiating around the hip to the right inguinal region. At operation the fifth process on the right was found to be movable and detached. The right fourth and fifth were removed. The patient now states that he has no more pain in the hip or groin, and pain in back is much less.

Case 18. J.P. Age 56 years. A white male laborer gave a history of back strain while lifting a heavy casting seven years previous to admission to hospital. For over two years he has had pain in the lower right back and radiating down the right leg while walking or stooping over. There was localized tenderness over the fourth and fifth transverse processes on the right. X-ray showed some arthritis of the second and third lumbar vertebrae. The fifth lumbar process on the right was removed. On the second day post-operative this patient had excruciating pain in the back and radiating down the right leg. This pain disappeared entirely when a collection of serum in the wound was evacuated. Patient was discharged at the end of eighteen days with no tenderness over the spine and complete disappearance of his previous subjective symptoms.

Case 19. J.S. A white male, age 48 years. Six years ago, fell ten feet from a scaffold and was confined to bed for eight weeks. He has been unable to work since, because of severe pain in the lower right back on walking or stooping over. He has had all manner of treatment without improvement. There was definite tenderness over the tip of the third lumbar transverse process on the right. The large tip was easily palpable. No radiation of pain. X-ray showed bilaterally enlarged processes of the third lumbar, otherwise the x-ray appeared negative. At operation the second process was found to be loose in its distal half and was removed in pieces. The long third process was also

removed. The patient was discharged from the hospital eleven days after operation with entire relief from previous symptoms.

Case 20. M.J. A white female patient 26 years of age, has had backache, pain in the groin, and occasionally numbness and loss of power in the hip since an accident several years ago, at which time she fell across an open drawer striking the lumbar region. She has been treated by various physicians and has received various diagnoses. A diagnosis of movable kidney has not been substantiated by examination in this hospital. She has, however, a palpable long, tender, transverse process on the right opposite the third lumbar. There is practically no other tenderness in the back. Motion is very slightly restricted and painful. After manipulation of the painful transverse process this patient complained of extremely severe pain in the groin and actual muscle spasm in the same region was observed. X-ray showed a long transverse process of the third lumbar with possible fracture near the tip. This patient has been advised to enter the hospital for resection of this process.

This group of cases does not include several of obvious recent fractures of transverse processes. These have been treated by removal but are not included in this group because their diagnosis did not depend, particularly, upon the points which I am attempting to emphasize.

The method of approach in the majority of cases has been through a longitudinal four to six inch incision over the offending processes and about two inches lateral to the spinous processes. The vertebral fascia is divided in the same line and the fibres of the erector spinae muscle separated by blunt dissection. The transverse process is bared, inspected, and freed from muscular and ligamentous attachment. The process is removed carefully with mallet and chisel, and the edges at the base rendered smooth. The close proximity of portions of the nerve trunks necessitates considerable care in this procedure. The fascia is closed with catgut and the skin with clips. In a few cases of large processes of the fifth, with impingement on the ilium, a modification of the approach first described by Bonniot (5) has been used. A vertical incision about 10 cm. in length and extending along and a little inside the external border of the sacro-lumbar mass is made. At the iliac crest it is continued inward, following the crest as far as the posterior inferior iliac spine. The muscle mass is separated with its periosteal attachment from the crest of the ilium, and a wedge of the crest is chiseled away and discarded. As much of the crest is removed as is necessary to expose the low lying fifth process. Closure is made by resuturing the muscle mass to the ilium.

Patients are placed on the back with a small pillow in the lumbar curve. Effort is made to prevent active movement for a period of seven or eight days. Only as much passive movement is permitted as is necessary for removal of clips, inspection of dressings, and care of patient. The period of recumbency has varied in individual cases from nine days to three weeks.

In the majority of cases that I have operated upon the symptoms have been present for long periods—months or years. During this interval some have received many different diagnoses and have had various methods of fixation, baking, etc., without relief. Several have been the patients of the chiropractor, osteopath, spondylotherapist, etc.

These cases are presented to emphasize the frequency of transverse process lesions as a cause of definitely localized pain in the back with accompanying lumbo-sacral neuritis.

In a number of these cases (11) transverse processes other than the fifth lumbar have been the site of the lesions. In four of these both the fourth and fifth were removed.

The x-ray has been a valuable assistance in the identification of abnormalities and certain cases of fractures. In several instances, however, the x-ray diagnosis of fracture proved erroneous. In three instances, fractures present, could not be identified on the x-ray.

Careful examination for points of tenderness, definitely localized, over transverse processes, has been of the greatest value in reaching a diagnosis. Location of these has been found of particularly great significance when accompanied by accentuation of referred pain.

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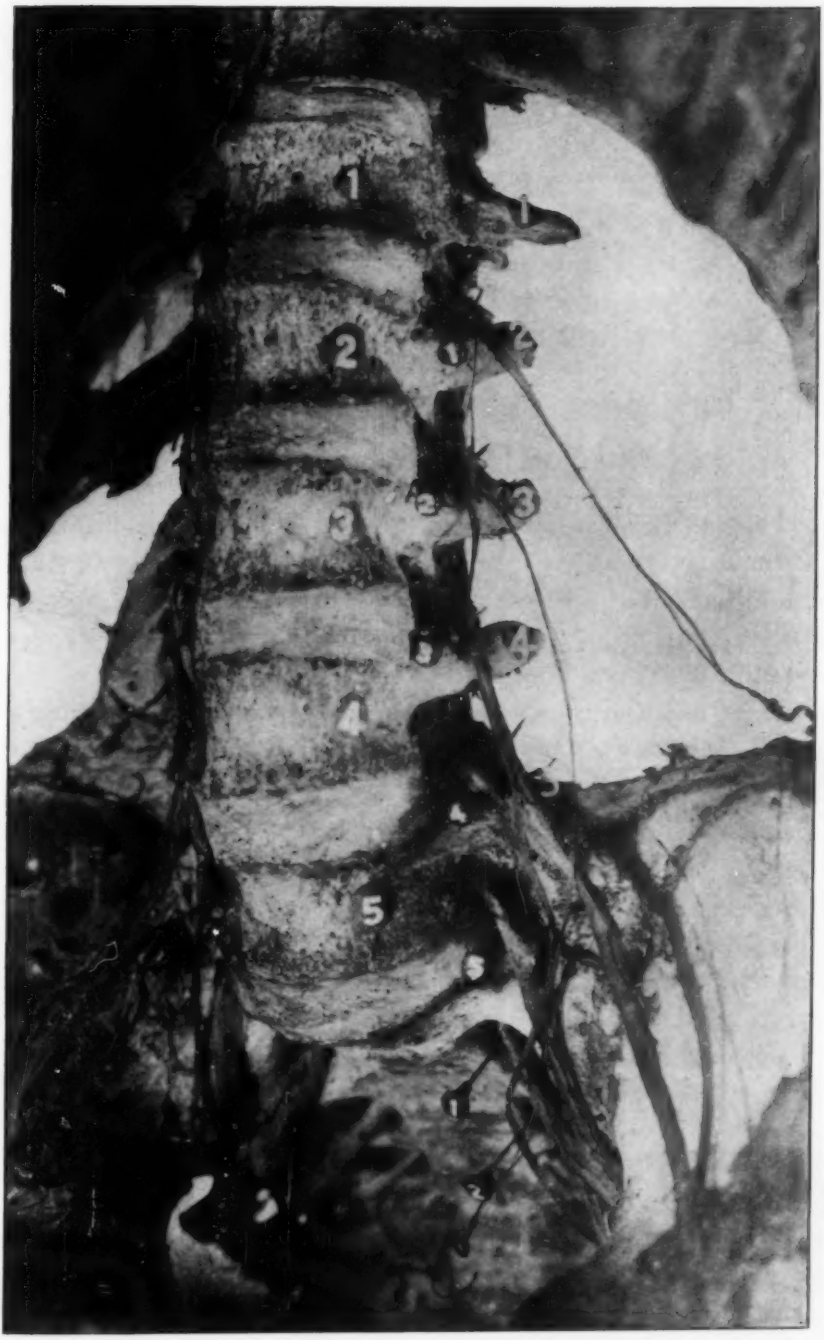

This dissection was made in the Department of Anatomy, School of Medicine, Western Reserve University. It was made particularly to show the intimate relation of the transverse processes and nerve trunks It is helpful to refer to this in explaining the location of the pain, especially in such cases as 8 and 20.

NON-SPINAL PSOAS ABSCESS

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THE frequency with which the orthopaedic surgeon is called upon to diagnose and treat psoas abscesses is due not only to the fact that there is involved an interference of locomotion, but also because it is generally believed that these abscesses are due to disease of the spinal column and the skeletal portion of the pelvis. There exists, however, a group of cases in which the spinal and pelvic bones play no part in the production of the suppuration. It is chiefly with this group of cases that we expect to deal in this paper. Our observations are based on a study of forty-two cases, of which twenty-four have come to our attention during the last four years.

ANATOMY.

The anatomical relationship of the retroperitoneal structures make the psoas sheath the avenue of choice for suppuration originating in these structures. The psoas muscle (Figure 1) has its origin in the sides and transverse processes of the twelfth thoracic and lumbar vertebrae, and courses downward to insert into the lesser trochanter of the femur. Posteriorly, it lies on the spinal column and the quadratus lumborum muscle. In its upper portion, it passes beneath the internal arcuate ligament of the diaphragm. Abdominally, it lies behind the peritoneum in close relation to the kidney, pancreas, and intestines. The vena cava and the genitocrural nerves lie anterior to it, while the lumbar plexus nerves course through it. In the lower portion, it runs over the superior ramus of the pubis, under Poupart's ligament, just under the femoral

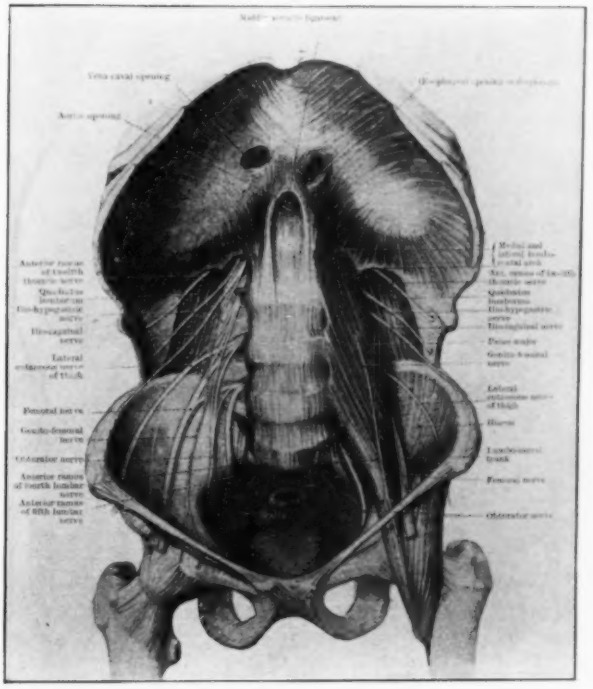

FIG. 1. The posterior abdominal wall, to show the psoas muscle. (After Cunningham.)

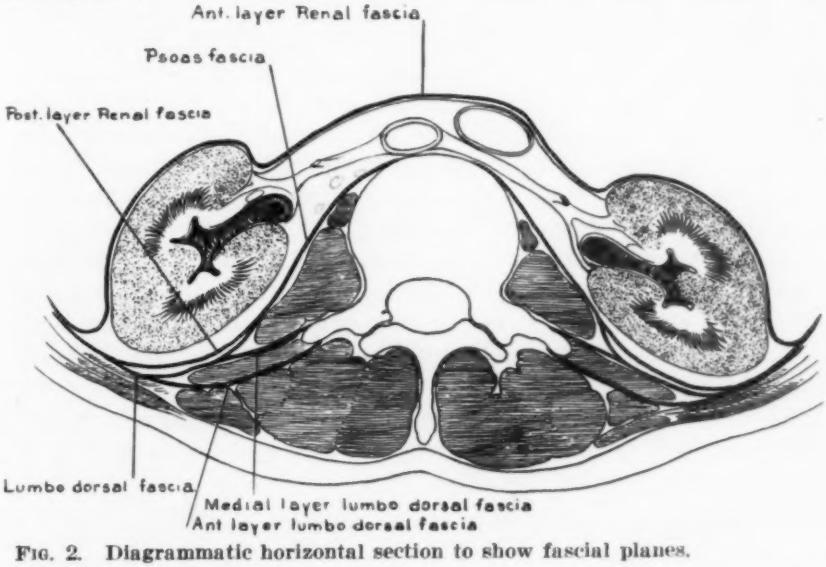

FIG. 2. Diagrammatic horizontal section to show fascial planes.

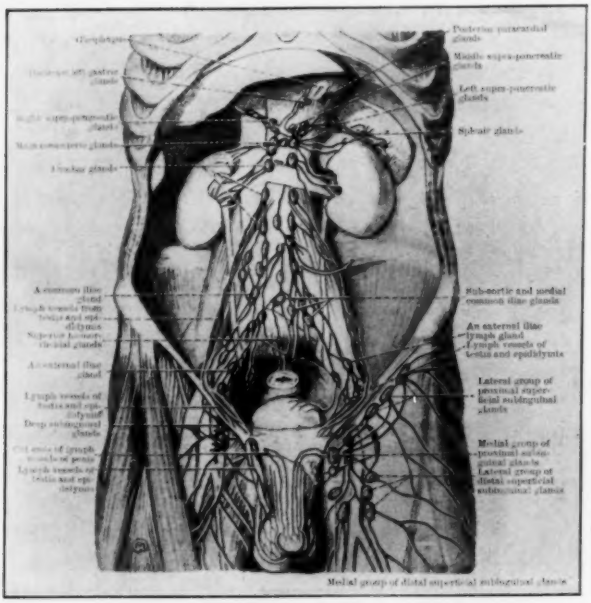
Posterior parietal glands
Middle supra-pancreatic glands
Left supra-pancreatic glands
Splenic glands
Sub-aortic and medial common iliac glands
An external iliac lymph gland
Lymph vessels of testis and epididymis
Lateral group of proximal superficial subinguinal glands
Medial group of proximal superficial subinguinal glands
Lateral group of distal superficial subinguinal glands
Medial group of distal superficial subinguinal glands

Fig. 3. Retroperitoneal Lymph Glands. (After Cunningham.)

vessels. A large bursa, the bursa iliopectinea, intervenes between the tendon of this muscle and the hip joint over which it runs.

The fascial planes play an important part in the determination of the course of the abscesses (Fig. 2). The kidneys are surrounded by the fascia renalis, which is open only on the infero-medial aspects, the anterior layer running from the peritoneal surface of one kidney across the midline, anterior to the aorta and the aortic lymph nodes, to join its mate on the other side. The posterior fascia fuses with the psoas and lumbodorsal fasciae. The last mentioned fascia has three layers. The anterior layer lies anterior to the quadratus lumborum and branches off medially into the psoas fascia in front of this muscle, and attaching to the prevertebral tissues, and another layer behind the muscle attaching to the transverse processes. The middle layer of the lumbar fascia lies behind the quadratus, and likewise attaches medially to the transverse processes. It is of significance that though the fascial planes at the level of the upper lumbar vertebrae are quite thin, in the lower portion, as the fascia iliaca, they become much thicker. (Spalteholtz.)

The lumbar lymph nodes (Figure 3), twenty to thirty in number, lie along the aorta between the level of the second lumbar vertebrae and

the bifurcation. There are a median row of four or five in front of, and five or six behind, the aorta, over the bodies of the third and fourth lumbar vertebrae, and two lateral rows consisting of a number of nodes on the successive heads of the psoas muscle. On the right side a few nodes are distributed in front of the vena cava. These glands drain a large area. The median row receives the lymph from the descending colon and the mesocolon; the lateral rows drain the muscles of the posterior abdominal wall and the iliac nodes, which in turn drain the legs, the testes, ovaries, Fallopian tubes and uterus, and the kidneys and suprarenals.

ETIOLOGY.

A review of our cases shows the sources of the abscesses to be manifold. A suppurative myositis of the posterior abdominal wall, whether the result of a metastatic infection or the result of an infected hematoma following trauma, will find in the psoas sheath the course of least resistance for the discharge of its pus. Infections of the solid viscera can likewise be responsible for such abscesses. Thus, infections of the kidney, particularly those which are not very fulminating, and have their origin in the lower pole of the kidney, find but little fascial interference as gravity directs them to the psoas. Retroperitoneal infections originating in the hollow viscera, or having been produced by extension from infection of the peritoneum, are not uncommon, and while they have the entire tela subserosa to penetrate, often find their way into the wide end of the psoas funnel. Infections of the internal genitalia, when they produce pus, do not ordinarily discharge it through the upper psoas region because gravity is against this, yet, when under considerable tension, such abscesses can break through the lower thicker fascia, to course in the regulation manner. Pleural empyemata have gravity to help them, but because of the interposition of strong structures do not frequently act as the producing factor. The existence of primary gangrene of the retroperitoneal fat is reported by Eliot.[1]

Last but not least we are confronted with the condition of suppurative lymphadenitis. When one considers the vast area drained by these glands, and when one remembers how common infection of the lymph glands is, one is not surprised by the frequency with which these glands are responsible for psoas abscesses, or by the variety of conditions which produce abscesses through their medium. One realizes how frequently lymphadenitis exists if one studies the more superficial chains such as

1. Eliot, New York Presbyterian Hosp. Reports, 1897.

the cervical glands. Because of the difficulty of observing and palpating the retroperitoneal glands, it is not easy to recognize an involvement of these glands unless they make themselves recognized through their effect on adjoining structures. Thus, when the infection of the lymph glands leads them to break down and produce pus, the suppuration will course down the natural path into the psoas sheath. One can see how metastatic infections from some distant focus may be responsible through the medium of these glands. Infections of the female genitalia, whether puerperal or non-puerperal, are frequent predecessors of the condition we are considering. The male genitalia, though naturally less frequently responsible, are nevertheless occasionally to be incriminated. Infections of the lower extremities have been found responsible through extension by the lymph channels.

Lumbar lymphadenitis of tuberculous origin, without any clinical evidence of primary involvement of the usual visceral sources, is relatively so common as to deserve special mention. We have repeatedly met cases of psoas abscess, previously classified as cases of Pott's disease (because of the recognition of tuberculous pus and the chronicity of the draining sinus), which on careful study and observation of the clinical course proved to be attributable to tuberculosis of the lumbar lymph nodes. Illustrative of this was patient G. S., who came to us, after having been treated for tuberculosis of the spine for one year, because of pain in the groin, a tuberculous psoas abscess, and a moderately rigid spine. Our repeated X-ray examinations showed no bony involvement. The sinus from the psoas abscess cleared up spontaneously in a few months. A year later the patient was engaging in rather severe exercise, such as prolonged horse-back riding, mountain climbing, etc., without any apparent spinal discomfort. X-ray again was negative for spinal involvement.

The organism which one finds in the abscess will naturally vary with the character of the initial lesion. Tuberculous lymphadenitis with suppuration will permit the isolation of the tubercle bacillus. In the more acute conditions, staphlococci, streptococci, and the other pus-producing organisms are found in various degrees of virulence. In our cases we have isolated streptococcus pyogenes, staphylococcus haemolyticus, stalphylococcus aureus, staphylococcus albus, B. coli, pneumococcus, and the tubercle bacillus.

COURSE OF ABSCESS.

Having found its way into the psoas sheath, the pus follows a definite course; that is, it travels downward towards the insertion of the iliopsoas muscle. Here no individual fascia exists; therefore, the abscess

collects near the pectineus and adductor longus muscles. After this the infection will travel one of several courses.[2] It may follow the superficial ramus of the middle circumflex femoris artery and point just medial to the psoas muscle. More commonly the pus enters the adductor triangle and points in the inner upper third of the thigh. Other courses are: a—dorsally along the circumflex femoris medialis artery, about the adductor minimus and quadratus femoris under the gluteal fascia to present itself dorso-laterally under the skin; b—along the sciatic nerve through the greater sciatic notch as an ischio-femoral abscess; c—under the iliacus fascia to appear just below Poupart's ligament, or occasionally to break into the sheath of the quadratus lumborum, then up the lumbo-dorsal fascia to present in Petit's triangle (Figure 4). It is quite conceivable that some abscesses will undergo resolution and spontaneously clear up. We have several cases which would fit into this group.

2. Loeffler, F., Ztschrft, für orthopädische Chir., XL., ii, July, 1920.

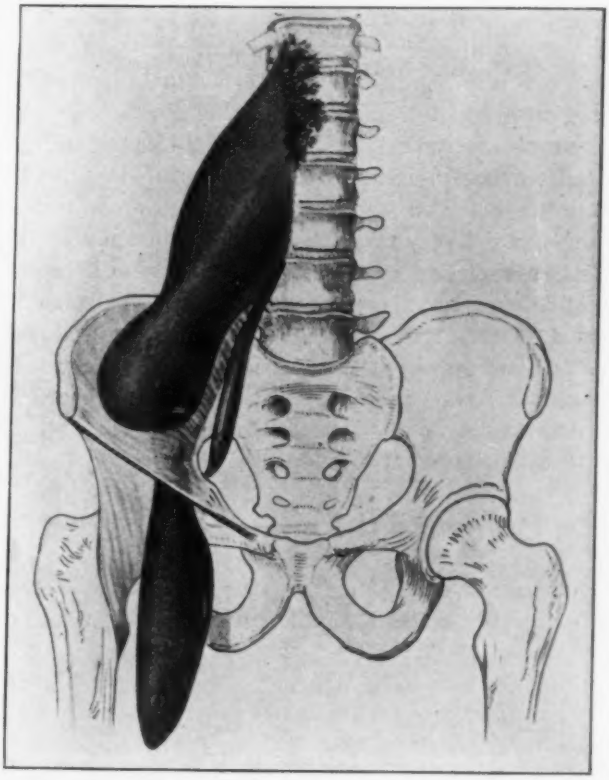

FIG. 4. Types of Psoas Abscesses. (After Loeffler.)

SYMPTOMATOLOGY.

The story that the patient brings, as a rule, falls into one of two general classes. In one group of cases the patient comes to us complaining of his "leg drawing up," or "limping on one side." On questioning one frequently elicits the history of an antedating injury. Following the trauma there is usually a latent period with gradual onset of vague symptoms of discomfort in the lower spine, sometimes becoming severe enough to be called real pain.

Not infrequently the symptoms referable to the back are entirely absent, and attention is first attracted by the appearance of an abscess or the drawing up of a leg. There may be some concomitant loss of weight, possibly some night sweats, and in some cases there may even be an afternoon rise of temperature. Pain in the thigh as low as the knee may be complained of.

On the other hand, there is a group of cases in which the patient is brought in acutely ill, usually unable to walk. The patient presents the usual signs of a septic condition, and seems to be suffering exquisite pain in the region of the lower back, hip, thigh, or knee on the affected side. Questioning may reveal the fact that three or four weeks previously the patient had a mild infection associated with an operative condition on the genito-urinary tract. Thus, a prostatectomy, an induced abortion, or a delivery may have been responsible for the infection at that time. Occasionally, one obtains a history referable to the gastro-intestinal tract or even to an abrasion on the leg. In some of our cases the local condition seems to have followed such general infections as scarlet fever. But whatever the symptoms may have been preceding the immediate condition, the symptoms of pain in the sacro-iliac region referred down the thigh to the knee and the deformity of the hip with the inability to walk are usually common to all.

PHYSICAL EXAMINATION.

On examining the cases one finds the following signs common to most of them: flexion deformity of the hip joint, *limitation of hyper-extension*, but freedom of abduction, adduction, rotation, and further flexion. With the patient standing, there is found considerable apparent spinal deformity, which, however, clears up in great part when the patient is

placed in a sitting position. There may persist a slight amount of lateral deviation of the spine, a "C" curve with the concavity on the affected side. With the patient in this position it is found that there is relatively free motion to the spine in all directions. Palpation and percussion of the spine produce no pain. Pressure, however, over Petit's triangle and over the sacro-iliac joint of the diseased side at times produces pain.

Abdominal palpation will often reveal some slight muscle spasm beneath which, in the lower lateral quadrant, it may be possible to distinguish an abnormal mass sensitive to pressure and frequently cystic in character. Pressure over this may produce pain referred to the knee. Examination of the knee reveals no pathology. In the more advanced cases the patient will demonstrate a tumor mass pointing in the groin or in one of the other favorite sites mentioned above. It may be possible by compression of these lower tumors to make them disappear, only to have them reappear when the pressure is removed.

In the acute cases in addition to the above symptoms one finds all of the objective findings referable to the febrile state.

The X-ray examination is of great assistance but a word is necessary with reference to the interpretation of the radiogram. Examination of the spine in the antero-posterior and more particularly in the lateral views will be negative for bone involvement. In interpreting X-rays of the hip and sacro-iliac joints one must be very cautious not to be misled by the hazing of the joints due to the super-imposition of the abscess over the joints. This mistake is very easily made, the writers having seen such hips reported "acute infection of the hip joint" by the very best X-ray diagnosticians. It is unnecessary, of course, to mention that shadows over the ilium are frequently due to intestinal contents.

DIFFERENTIAL DIAGNOSIS.

The difficulties that one encounters in differential diagnosis will be recognized when one observes that our cases were variably diagnosed by good clinicians as arthritis of the hip, arthritis of the sacro-iliac joint and spine, Pott's disease, trauma of the spine, tuberculosis of the hip, femoral hernia, tumor of the thigh, broad-ligament abscess, pelvic inflammatory disease, and sciatic neuritis.

The differentiation of hip infections from psoas abscess is often quite difficult. In both, one finds a limp, and in both the leg is held in abduction, external rotation, and flexion. The keynote of the differentiation lies in the ability in psoas abscesses to move the hip through an

arc of motion without severe pain, *if the hip is flexed;* whereas one generally finds limitation of motion in the hip joint in any arc of motion when the hip joint itself is diseased. In psoas conditions one does not find a persistent contraction of the adductors, as one is apt to note in hip involvements. Furthermore, in the chronic conditions, such as tuberculosis, the atrophy of the thigh in psoas conditions is slight, whereas in hip conditions it is quite pronounced. Usually in psoas abscesses one will not find sensitiveness on local pressure on the posterior surfaces of the hip or on centripetal compression of the trochanters, such as one often notes in hip conditions. Again, the pains in hips are referred to the front of the knee, whereas, generally in psoas conditions the pains are felt in the lower lateral back, radiating down the thigh, forward and downward.

Other conditions of the hip can easily be ruled out by the usual measurements which in psoas conditions will be found to be normal.

Spinal conditions are more easily eliminated. Have the patient sit on the edge of the bed or table and test the spine for mobility. A spinal lesion severe enough to produce an appreciable abscess will produce much more limitation of motion than is found in cases of non-spinal psoas abscesses. Herniae or tumors of the thigh can be thought of only in advanced cases, when the abscess is already pointing, at which time the location of the infection, the sense of fluctuation, and the compressibility can differentiate the conditions. The usual pelvic conditions can be recognized by pelvic examination, and when the existence of the psoas lesion is borne in mind should offer no difficulty.

Osteomyelitis of the sacro-iliac joint, a rare condition, is not to be diagnosed merely on the appearance of a shadow over the ilium. Involvement of the sacro-iliac joint, it will be recalled, is usually associated with limitation of motion in the spine. In the presence of psoas abscess, the normal sacro-iliac joint behind the fluid may appear hazy on X-ray, or, from the distortion of the pelvis incident to the hip deformity, may appear different from the joint of the healthy side. Extreme caution must be observed before incriminating either of these structures.

The recognition of the factor behind the psoas abscess will depend on two points, first the history, and second the process of elimination. A recent pregnancy, abortion, or miscarriage, particularly when followed by a febrile condition, must always be considered with suspicion if a psoas abscess develops. Symptoms of an antedating pyelitis will incrim-

inate the kidney. A concomitant sore throat will lead one to look for the primary focus in the infected tonsils. Gastro-intestinal symptoms usually precede psoas abscesses of gastro-intestinal origin. A recent injury to the back will suggest an infected hematoma.

TREATMENT.

Treatment of the condition will vary with the character of the infecting organism, and the size and location of the abscess. Puncture of the abscess by needle for the purpose of evacuation or diagnosis has been described by Calot. When the abscess is superficial, treatment is simple. When the abscess is small, however, and has not presented any visible tumor, it can be reached by inserting the needle just above the middle of the proximal half of Poupart's ligament upward and backward at an angle of twenty-five degrees (Figure 5). Evacuation of the abscess is reported by vaginal puncture. For careful surgical approach and examination, however, it is necessary to do a more elaborate dissection. An incision is made over the crest of the ilium, from the anterior superior spine backward a distance of eight cms. The incision is carried through the external and internal oblique muscles and transversalis fascia to the peritoneum, which is then stripped forward to expose the psoas

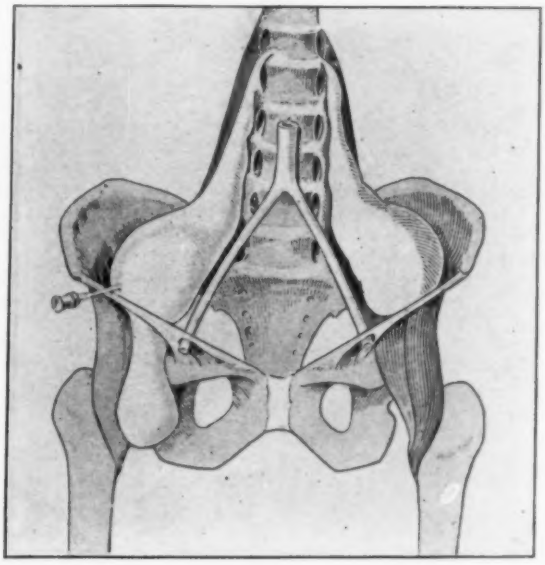

FIG. 5. Aspiration of Psoas Abscess. (After Calot.)

muscle. Through this incision, examination can be made from as high as the kidney to as low as just beyond the linea terminalis. Treatment of the abscess will then follow accepted surgical principles—drainage in cases of septic infections, and evacuation and closure in cases of tuberculous lesions.

As a rule, after evacuation of the abscess, the hip deformity clears up. The septic infections will drain for a while and then close. The tuberculous sinuses drain much longer, but the condition does not have the serious prognosis associated with infections of the spine.

SUMMARY.

In conclusion, we desire to call attention to the facts, first, that there exists a large group of cases of psoas abscesses which originate from sources other than spinal or pelvic bone involvement; second, that lymphadenitis of the retroperitoneal lymph glands exists with either a tuberculous or a septic organism as the infecting agent; and third, that these conditions are to be clearly differentiated from spine or hip involvement.

Book Reviews

A Manual of Corrective Gymnastics. By LOUISA C. LIPPITT. New York: The MacMillan Company, 1923.

The author says in the preface of her book, "With the increasing demand for corrective gymnastics in the schools as well as in the colleges, it has become necessary to stress more and more this branch of physical education in the training of instructors for this work." . . . "In my own work as director of corrective gymnastics for girls in the University of Wisconsin, I have felt the need of a book which would give exercises for the many types that are treated in a corrective gymnasium and which could be used both as a text book and as a reference book."

The author has adhered very closely to her plans throughout the book, and anyone reading it will get many very helpful suggestions. Chapter 4—Giving Physical Examinations and Assigning Students to Classes; Chapter 5—Corrective Exercises in Classes and with Individuals; Chapter 6—Corrective Exercises for Small Children and Older People, and Chapter 7—What is Correct Posture and Why is it Necessary? will give anyone an excellent plan upon which to build up his work in this line.

Pathological Physiology of Surgical Diseases. By PROFESSOR DR. FRANZ ROST, University of Heidelberg. Authorized Translation by STANLEY P. REIMANN, M.D. Philadelphia: P. Blakiston's Son & Co., 1923.

The authors are to be congratulated on presenting this unique volume correlating these two fundamental sciences.

It is of great value to the general surgeon, physiology being our greatest ally in the management of surgical cases before and after operation. The book being a careful compilation of the experimental literature with a very complete German bibliography makes it particularly helpful to the teacher of surgery.

The upper class students and hospital internes will now find the answer to many questions that are constantly occurring to them during their hospital rounds, as the translator's clear diction and his added notes from American and English, as well as more recent foreign, literature bring the work fairly well up to date, and gives a concise idea of the amount of experimental work necessary to establish facts concerning physiological changes necessary to bring about known pathological lesions.

There is one chapter on the extremities which should be of interest to the orthopædic surgeon.

News Notes

With the deepest regret we announce the death on Friday, May 11th, of Dr. William G. Erving, of Washington, D. C., a member of the American Orthopedic Association since 1908.

The programme of the fourth regular meeting of the Chicago Orthopædic Club, held on the evening of May 11th, 1923, was as follows:

Bilateral Sacro Iliac Obliteration.—Dr. S. C. Woldenberg.

Radius Curvus (Madelung's Deformity).—Dr. Beveridge H. Moore.

Some Orthopædic Conditions of the Knee Joint.—Dr. Charles A. Parker.

For those who wish to study in France this summer, it is announced that Dr. Hallopeau will give a course of clinical instruction consisting of ten lessons on non-tuberculous affections of the osseous system in children. This course will be given from the 2nd to the 13th of July, at the Hopital Trousseau, Paris, and will be followed by a course at Berck, between the 16th and the 29th of July, given by Dr. Sorrel and other members of the Maritime Hospital.

Further information may be obtained by writing to Dr. Parin, Hopital Maritime, Berck-Plage, (P. de C.), France.

The Section in Orthopedic Surgery, New York Academy of Medicine, met on the evening of March 16th.

The following programme was carried out:

PRESENTATION OF CASES. From the Hospital for Joint Diseases.

(a) Cases of Köhler's disease. Albert L. Levy (*by invitation*).

(b) 1. Club feet. 2. A new operation for bow-legs. Henry W. Frauenthal.

(c) Wrist tumor; operation: findings. Samuel A. Jahss (*by invitation*).

(d) Post-encephalitic hemiplegias. Charles Rosenheck (*by invitation*).

(e) Pathological fractures through bone cysts. Harry C. Stein (*by invitation*).

(f) Neurotrophic disturbances of bones and joints. Harry Finkelstein.

(g) Interesting x-ray plates. Herman B. Philips (*by invitation*).

(h) Cases illustrating the paper of the evening. Angelo L. Soresi.

PAPER OF THE EVENING. "The open reduction of fractures, without the help of any foreign body." Angelo L. Soresi.

At another meeting, on April 20th, the programme was as follows:

PRESENTATION OF PATIENTS AND REPORTS OF CASES. (From Fordham Hospital.)

(a) Bone grafts (5 cases). Alexander Nicoll.

(b) Severe infectious monarthritis (4 cases); osteomalacia; Sarcoma of the fibula. Samuel W. Boorstein.

(c) Radiographic plates of interesting bone cases. Isidore J. Landsman (*by invitation*).

PAPER OF THE EVENING. "A practical consideration of the union of fractures." Illustrated with lantern slides. Edwin W. Ryerson, of Chicago (*by invitation*).

On the evening of May 18th, the following programme was presented:

PAPERS:

(a) "Fracture of the anterior superior spine." Louis Carp.

(b) "Treatment of bone abscess by evacuation through a small drill hole." Walter M. Brickner.

(c) "The operative treatment of old congenital dislocations of the hip." Illustrated by lantern slides. A Bruce Gill, of Philadelphia (*by invitation*).

Dr. Alonzo Myers, of Charlotte, N. C., announces that henceforth Dr. J. Stuart Gaul will be associated with him in the practice of orthopædic surgery.

The Eastern States Orthopædic Club met in Pittsburgh on May 11th and 12th, 1923.

The clinics were well run and of great value. They were attended with interest and aroused beneficial discussion.

The following programme was presented:

CHILDREN'S HOSPITAL—FRIDAY, MAY 11, 9 A. M.

Tuberculosis of spine:
1. Demonstration of frame treatment.
2. Demonstration of cast.
3. Demonstration of brace.
4. End results of treatment.

End results of sarcoma of spine after operative removal.
Demonstration of scoliosis brace.
End results of open operation congenital hip.
Infantile paralysis:
1. Transplantation of peroneals to dorsum foot.
2. Stabilizing operation on talipes equino-varus.
3. Stabilizing operation on completely paralyzed flail foot.

Dr. Wallace, Dr. Markell.

MERCY HOSPITAL—FRIDAY, MAY 11, 2 P. M.

Syphilitic aortitis. Dr. Ritchey.
Surgery of blood vessels, with report of successful suturing of femoral artery. Dr. Seiber.
Relation of focal infection to arthritis. Dr. Lichty.
Synovectomies and bursectomies. Report of 2 cases. Dr. Wallace.
1. Fractures of pelvis.
2. Fractures of bones of forearm. Dr. Well.

Internal derangements of knee joint. Dr. Wallace.
End results of crush fractures of spine. Dr. Wallace.
Arthroplasties:
(*a*) Results. (*b*) Problems of ankylosis of hip. Dr. Wallace.
Ward Rounds.

CLINIC FOR EASTERN STATES ORTHOPÆDIC CLUB—ALLEGHENY GENERAL HOSPITAL, 8.45 A. M., MAY 12, 1923.

Operative treatment of hallux valgus. Drs. Silver, Steele and Yount.
Observations in European clinics, with especial reference to prosthesis. Dr. Yount.
A statistical study of operative and non-operative results in spinal tuberculosis. Dr. Steele.
(*a*) Method of gradual correction of loss of hip flexion.
(*b*) Method of treating fracture of clavicle.
(*c*) Clinical experience with the Willems' treatment of infected joints. Dr. Mooney.

A few observations on the treatment of tuberculosis of the hip. Dr. Silver.
Statistical report on osteomyelitis. Dr. Steele.
A study of the value of artificial limb suspender control in infantile paralysis. Dr. Yount.
Methods used in the treatment of industrial fractures. Dr. Alexander.
Experimental encephalitis with the virus of herpes labialis: a preliminary report. Drs. Goodpasture and Teague.
Exhibit of orthopædic instruments, splints and equipment.

Current Orthopaedic Literature

SECONDARY OS CALCIS. Arthur Krida, M.D. *Journal American Medical Association*, March 17, 1923.

CONGENITAL DEFECTS

Dr. Krida reports a case of secondary os calcis of the right foot of a man of 30 who suffered from recurring sprained foot. The skiagraph seemed to show a fracture of the anterior processus calcanei, but at operation he found a rudimentary os calcis across the middle of the calcaneo-cuboid ligament above the ligaments and upon the dorsum. He quotes Dwight, Pfitzner and other investigators of the subject. The paper is illustrated with two half tones. His conclusions follow:

CONCLUSIONS.

From the clinical standpoint, the separate ossicle described by Pfitzner may be accepted as the typical secondary os calcis. Its occurrence in 2 per cent of his large series of dissections need not lead to the expectation of finding it frequently in routine roentgenograms of the foot, as the smaller and less well developed specimens might easily escape demonstration.

It would seem that a well developed secondary os calcis, acting like a wedge in a series of complicated movements in the middle of the tarsus, would be peculiarly liable to avulsion or displacement.—*H. A. Pingree, M. D., Portland, Me.*

CONGENITAL DISLOCATION OF THE HIP, WITH INTRACAPSULAR EXOSTOSIS. Carroll D. Storey. *Journal American Medical Association*, March 31, 1923, page 914.

This is a case report of a girl, aged 13, who had suffered from a limp since walking commenced. Relief was not sought until the child was 11 years old. There was 1¾ inches of shortening. Clinical diagnosis was congenital dislocation of the hip. X-ray examination confirmed this and showed in addition a large exostosis projecting from the under surface of the neck of the femur.

Operation by anterior route disclosed an exostosis 1½ inches long and ¾ inch thick at its narrowest part. The growth was entirely intracapsular. The

exostosis was removed and an attempt was made to reduce the hip, but was unsuccessful. The wound was closed, heavy traction was applied for three weeks, and the dislocation reduced with the aid of the Bradford machine. The final outcome was that the "hip is practically stiff in 25 degrees of flexion and 15 degrees of outward rotation. The patient is able to walk without fatigue and without pain." So far as the author knows this case is unique. —*Alexander Gibson, F.R.C.S., Winnipeg.*

CORRECTION OF CONGENITAL CLUB FOOT. E. H. Bradford. *N. Y. Med. Jour. and Med. Record*, Feb. 7, 1923.

After correction of club foot deformity the pressure on the sole in walking should be normally distributed, not chiefly upon the fifth metatarsal. After correction a shoe with a thick wedge under the cuboid helps to correct such a tendency. Permanency of cure of club foot is attested by cases treated twenty and thirty years ago.

After referring to various methods of treating neglected club foot, the author describes a procedure using an osteotome for severing the internal lateral and astragalo-scaphoid ligaments subcutaneously, likewise; in some cases, the calcaneo-cuboid ligaments, together with wrenching and Achilles tenotomy. Some cases require a two stage procedure.—*R. W. Billington, M.D., Nashville.*

NON-TUBERCULOUS ARTHRITIS

EXERCISE IN ACUTE INFECTIOUS ARTHRITIS. S. W. Boorstein. *N. Y. Med. Jour. and Med. Record*, Feb. 7, 1923.

This applies to acute cases which later become chronic. Causative infectious foci are to be removed when possible. Treatment should begin early while redness and swelling still exist. The joints are usually put in plaster splints for about ten days, then baking, massage, and exercise are begun together with occupational therapy under the direction of a trained attendant. The patient should be out of bed as soon as possible. Persistent effort and encouragement are needed. Lasting pain and swelling after exercise show that the joint has been over-used. Three cases are reported.—*R. W. Billington, M.D., Nashville.*

ON A MANNER OF ONSET OF CHRONIC VERTEBRAL RHEUMATISM. Bufnoir and Legras. *Revue d'Orthopédie*, September, 1922, p. 429.

Case 1. Woman, age 27. Pain in back beginning in 1915 and increasing until April, 1918, she had to have a plaster jacket put on. Improved with rest so that in October she could go without the jacket, but pain came on again

and she had to have another jacket in January, 1919. Tenderness and pain in mid-dorsal region, but no kyphosis. Jacket removed in May, but had to be put on again. Pain was ameliorated by heliotherapy. Roentgenogram showed small loose bodies on the anterior border of the vertebral column, one each at the VI, VII, VIII, and IX dorsal intervertebral space. These bodies were symmetrical in shape and of the same density as bone. Patient had to keep wearing a celluloid jacket, but was able to work.

Case 2. Man of 42. Diagnosis of Pott's disease had been made. Pain and tenderness IV D to VIII D vertebra. Had typhoid at 28. A swelling developed on the left forearm which was opened and a small sequestrum extracted. Spine ultimately became stiff. Roentgenogram showed detached bodies on anterior border of bodies at the V, VI, and VII dorsal intervertebral spaces. After these findings and clinical course a diagnosis of infectious arthritis was made. Improved under heliotherapy and rest. Able to go back to work after a year and a half.

Case 3. Man of 62. Constricting pain at level of last ribs. History of lues, but negative Wasserman. Parathesia of sphincters. Obtuse kyphos in dorsal region. Roentgenogram showed narrowing of VII and VIII dorsal vertebral bodies and of spaces between V, VI, and VII D. Osteophytic lipping on anterior margins of these vertebrae and a detached small body of bony density between VIII and IX D. Unable to walk without support. Marked improvement with rest, heliotherapy, and arsenobenzol.

Case 4. Woman of 34. Came to Cannes in a plaster bed, with a diagnosis of Pott's disease. Sharp pain along entire spine. No kyphos. Negative roentgenogram except for a small detached osseous body at the anterior superior border of VII D. Because of character of pain and roentgenographic findings the diagnosis of Pott's disease was abandoned. Improved with rest and heliotherapy.

Case 5. Woman of 37. Sharp pain in back coming on rather suddenly and lasting several weeks followed by dull pain. Another sharp attack six months later. Roentgenogram showed an opacity in the space between IX D and X D. Patient had pulmonary tuberculosis but spinal condition was not tubercular.

These cases show that infectious arthritis may simulate tubercular spondylitis. But when carefully analyzed it is found that the pain is sharper than in tuberculosis and the roentgenogram is different. Free ossified bodies are frequently found in addition to lesions in the body of the vertebra. The prognosis is not bad. Most cases improve sufficiently to return to work in one to two years. Some flexibility may return in the spine.

The only unusual thing about these cases is the presence of the detached osteophytes.—*William Arthur Clark, M.D., Pasadena, Calif.*

A Case of Septic Arthritis in an Infant. A. MacKenzie Forbes. *Canadian Med. Assoc. Journal*, Feb., 1923, p. 118.

This is a case report concerning a baby three weeks old, suffering from a swelling in the upper half of the left thigh. The baby was breast fed, and

had been restless for three or four days, but not feverish. A large, tense swelling was present, the skin over it of a purplish-red hue, with vesicles increased in number and dilated. Fluctuation was not elicited, though the tumor suggested a deep seated collection of fluid. A haematoma arising from an angioma was thought likely, there being no evidence of infection through the navel or respiratory tract, and no elevation of temperature. Exploration by needle followed a sudden rise in temperature and pulse. Pus was found and evacuated freely by deep incision, but the baby died in a few days from septicaemia. The seat of infection proved to be the hip joint. Septic arthritis, as in this case, usually begins about the second or third week, and about 75% of the cases die of septicaemia, even when thoroughly drained.—*J. A. Nutter, M.D., Montreal.*

CHRONIC INFECTIOUS ARTHRITIS. Ralph A. Kinsella, M.D. *Journal American Medical Association*, March 10, 1923.

Dr. Kinsella has given us a paper that is rather confusing and one which it is impossible to sum up in an abstract. He has, however, seen clearly a good many points to which not much attention is paid, and has frankly stated them. His comment follows:

COMMENT.

The most significant features of this study have been:

1. The emphasis given to the part which circulatory changes and consequent nutritional changes play in the production of painful stiffening of the joints in which simple atrophy is the only evidence on roentgen-ray examination.

2. The importance of exhaustive physical examination in the search for infected foci.

3. The necessity of employing many forms of treatment, since no form was constantly successful and each kind of treatment was occasionally successful.

4. The importance of the last described group of male patients whose chief symptom is backache and who have spinal osteoarthritis, apparently associated with prostatic infection.

5. The lack of evidence that arthritis deformans is a focal infection.—*H. A. Pingree, M.D., Portland, Maine.*

NEOPLASMS.

AN UNUSUAL FOREIGN BODY IN THE KNEE JOINT. Jean Madier. *Paris Médical*, November 25, 1922, p. 471.

A case is reported as follows:

Boy of 12 had a fall on his knee, which made a wound just under the patella. This happened in July, 1918. The knee was immobilized for a month and there was evidently no infection of the joint. Roentgenogram showed nothing abnormal and the child was permitted to walk. For the next two years he had several periods of trouble with the knee, during which there was pain, swelling,

and limitation of motion. Examination in March, 1921, showed muscular atrophy in the affected leg, fluid distension of the joint, incomplete extension and flexion. Roentgenogram then showed a foreign body slightly more opaque than the bone lying over the anterior spine of the tibia. The case went on with more or less trouble until January, 1922, when the child was brought to the hospital again. The foreign body was then palpable over the internal condyle, where it made a visible bulge on the surface. Roentgenogram showed that it had shifted its position from near the center of the joint. Operation for removal was done and the foreign body was found to be a piece of glass. Recovery was uneventful. Five months after the operation the patient had had no more trouble, could extend the leg very well, and could walk and run without hindrance.

The salient points brought out in this case are: (1) There was no general infection of the joint at the time the glass penetrated it. (2) The joint tolerated a piece of glass with sharp edges for two years and a half. Foreign bodies which are retained so long a time are usually lead or other smooth pieces. (3) It was not possible to determine the nature of the foreign body by roentgenography.—*William Arthur Clark, M.D., Pasadena, Calif.*

MYELOMA OF THE VERTEBRÆ. Robert B. Osgood. *Boston Med. and Surg. Journ.*, March 22, 1922.

Dr. Osgood calls attention to this unusual tumor on account of its occasional simulation of the more common diseases of the spine,—in particular, tuberculosis,—and emphasizes the need of such a presentation by the fact that the ante-mortem diagnosis of myeloma was made in only one of the three cases reported by him. All cases had pain in the back as a predominating symptom and when x-rayed showed diminished density of a few to several of the dorsal and lumbar vertebrae, with partial collapse of some, but with very slight kyphos.

Brace treatment, as in tuberculosis, improved them for a time, and in one a bone graft was inserted with temporary relief. Other bones became affected, with fractures of the femora in one and circumscribed areas of softening in the skull of two others. The duration of back symptoms in one was two years, in another six years, and in a third, four years. This patient was still living when this report was made. Bence-Jones protein test was positive in only one of the three. No specific treatment is mentioned, though protection of the spine as in caries is indicated.—*C. A. Parker, M.D., Chicago.*

CYSTS OF THE EXTERNAL SEMILUNAR CARTILAGE OF THE KNEE. D. B. Phemister. *Jour. A. M. A.*, March 3, 1923, p. 593.

Two cases are reported with a careful pathologic examination in each case. The pathologic findings in these cases are identical with those of colloidal cystic swellings which develop in various connective tissues, such as come on the back of the wrist, and are commonly called ganglions. Most of the cases

occur in young adults and more in males than females. Trauma plays a slight role in these cases. The lesion has never been observed in the internal semilunar cartilage. Treatment consists in operative removal of both cyst and external semilunar cartilage. When only the cyst is removed there is usually a return of symptoms and a secondary operation is necessary.—*Edward S. Hatch, M.D., New Orleans, La.*

FRACTURES, DISLOCATIONS AND OTHER TRAUMATA.

FRACTURES OF THE THIGH IN CHILDREN. Rene Bloch. *Revue d'Orthopédie*, September, 1922, p. 447.

Fracture of the femur is more common in boys than in girls, 410 to 129. Bilateral fracture was found in only six cases out of 537. Left femur 299 times to 240 on the right.

The mechanism may be direct violence, bending, jamming, or torsion. Direct violence is a frequent cause, usually from running against an obstacle or being run over by a vehicle. Flexion fractures are produced by a fall on the knee or foot which bends the thigh forward, breaking the femur. Longitudinal jamming of the bone may produce a rather rare telescoping fracture. Torsion fractures are oblique and are the most common. The usual mechanism is a fall with leg turned outward (sometimes inward) the weight of the body twisting the femur, the lower end of which is fixed by the position of the leg on the ground.

The fracture may be sub-periosteal, such as the telescoping fracture, but in the incomplete or "green-stick" type the periosteum breaks on the convex side.

Subtrochanteric fractures are rare in children. The break is usually in the middle third or at the juncture of the middle and upper thirds.

The oblique type is quite common, 115 cases in 157. There is always overriding with the proximal fragment anterior and sometimes adducted, due to muscle pull. A third fragment, triangular in shape, is often found but it does not complicate the union.

Formation of callus is much more rapid in children than in adults. Good immobilization makes for good development of the callus; it will form without immobilization, but it becomes excessive and may interfere with function.

In diagnosis, there is usually not much chance for error in a complete fracture of the femoral shaft. With the patient lying down, the leg lies in external rotation and there is usually more or less antero-external bowing of the thigh. A good method of examination is to place the hand, palm up, under the thigh and make upward pressure. Abnormal movement and crepitation can thus be noticed. Ecchymosis may be present and may serve as a valuable diagnostic sign in green stick fractures.

Subperiosteal fractures do not show deformity or shortening. Such a fracture may be discovered by eliciting a definite point of tenderness on deep palpation by testing the flexibility of the bone and by roentgenogram in two planes. Green stick fractures show bowing but no shortening.

The prognosis of these fractures in children is excellent. Union takes place in about a month. There remains very slight, if any, shortening, or the broken femur may even be a trifle longer than the sound one if a rachitic curve is present. Late results are equally good. A femur which may have had slight bowing deformity becomes as straight as the good femur in a few years, and excess callus disappears.

Simple extension is the best method of treatment. The vertical extension commonly used in America is deemed unnecessary.—*William Arthur Clark, M.D., Pasadena, Calif.*

MYOSITIS OSSIFICANS TRAUMATICA. Dudley Carleton. *Boston Med. and Surg. Journal*, March 22, 1923.

Carleton reports two cases occurring in a large surgical experience of over 25 years, the small number thus attesting their rarity.

One of these extended forward from the coronoid into a hematoma following a severe injury, and the other developed in the substance of the adductor longus muscle after an injury accompanied by a large ecchymosis had occurred in the right groin. He believes with Painter in a recent article that their origin "is that of periosteal transplant and liberated osteoblasts caused by the rupture of muscle attachment from bone, with the tearing off and retraction of periosteum into the muscle structure."—*C. A. Parker, M.D., Chicago.*

THE SO-CALLED RAILWAY SPINE. F. Walter Carruthers. *Southern Med. Jour.*, March, 1923, p. 216.

The anatomic relations of the spine are taken up and the skiagraphic and physical findings discussed, and a plea is made to correlate these. A careful examination and skiagraph of all cases of back trouble in industrial cases should be on record as a check on future trouble.

One case of fracture of the 12th dorsal vertebra is reported.—*Edward S. Hatch, M.D., New Orleans, La.*

CHRONIC NON-INFLAMMATORY LESIONS OF THE KNEE JOINT. M. S. Henderson. *Archives of Surgery*, January, 1923, p. 118.

After discussing the anatomy and physiology of the knee joint, the following lesions are discussed. (1) Sprains. Here the internal lateral ligament is generally involved. Damaged semilunar cartilage is ruled out by absence of locking. Rest for a few days, baking, and massage are usually effective. If pain and tenderness persist, the inner side of sole and heel should be raised to remove the strain from the internal lateral ligament. (2). Ruptures of the crucial ligaments. This condition would seem to be infrequent. In the

few cases seen by the writer, excellent function has been obtained by the use of a plaster-of-paris cast in a slightly flexed position. (3). Intra-articular fractures of the knee joint. Severe trauma may produce fracture of the tibial tuberosities or of the femoral condyles. Very little can be done for such patients. The condition of disability is usually not severe enough to warrant an ankylosing operation. When seen early such cases should be treated by early motion, which is less painful when carried out under extension. It is doubtful whether an early open operation would secure better position of the fragments. (4). Recurring dislocations of the patella. These are always outward. Reefing the inner capsule after lengthening the outer capsule acts satisfactorily. The condition is most commonly seen in women. (5). Old ununited fractures of the patella. These are difficult to treat. The disability may be great or but slight. The fragments must be brought together without tension, even though the upper fragment is dissected entirely free and used as a graft to the lower. The gap left is obliterated by sutures, the fragments are held together by beef bone screws, kangaroo tendon, or wire. (6). Intrinsic mechanical derangements of the knee joint. Of these, the internal semilunar cartilage is the principal source, the loop or bucket-handle type of tear being most frequently seen. The external semilunar, thanks to its loose attachment at the periphery, usually escapes injury. Reduction by manipulation of a displaced cartilage is described, also the operation for its removal. Another source of mechanical derangement is the presence of loose osteocartilaginous bodies. These are produced by three conditions: 1, osteochondritis dissecans; 2, hypertrophic arthritis, and 3, osteochondromatosis. Osteochondritis dissecans rarely sets free more than one or two bony masses, usually from the internal condyle near the insertion of the posterior crucial ligament. The etiology of this condition is not yet clear. In hypertrophic arthritis, loose bodies are produced by the breaking off and dropping into the joint of marginal outgrowths. These wander about and increase in size; four or five may be present, normally in elderly persons. In osteochondromatosis the synovial membrane, from some developmental defect, takes on the property of forming osteocartilaginous bodies, which may reach a large number. We do not know why this occurs. The presence of loose bodies of any origin is an indication for their removal. Often this can be done under local anaesthesia. When the bodies are multiple the split-patellar route is the method of choice.—*J. A. Nutter, M.D., Montreal.*

FRACTURE OF THE HEAD OF THE FEMUR, WITH DISLOCATION ON THE DORSUM OF THE ILIUM. Guy Hinsdale. *Jour. A. M. A.*, Feb. 17, 1923, p. 469.

Reported on account of the rarity of fracture of the femoral head. A woman of 55, weight 160 lbs., fell, striking her hip in an extreme position of the limb. After the accident the deformity typical of dorsal dislocation of the hip was present, with about three inches of shortening. Efforts to reduce the hip by manipulation proved ineffectual. X-rays showed one-third of the head of the femur, including, it was found later, the insertion of the ligamentum teres, lying on the lower acetabular margin. The dislocation was reduced

by open incision, the fragment first being removed. Recovery was prompt and satisfactory. The author discusses the possible mechanics of the fracture-dislocation, considering it likely that the leg was at first forced into an abnormal position and then by a fall the head was broken against the acetabular brim, permitting full dislocation.—*J. A. Nutter, M.D., Montreal.*

INJURIES TO THE CRUCIAL LIGAMENTS AND AVULSION OF THE TIBIAL SPINE. Charles F. Painter. *Boston Med. and Surg. Jour.*, Nov. 30, 1922.

Knee joint surgery has advanced rapidly during the last twenty years. Surgeons no longer hesitate to open and explore a clean knee joint, when correct surgical technique is available. The author lays stress upon the extraordinary stability of the knee joint mechanism and the way in which that stability is secured. He describes briefly the anatomy and the physiology of the joint, and then gives a description of four cases under his own care, the first three having torn one or both crucial ligaments, and the last one having a fracture at the base of the spine of the tibia. The first and fourth cases were treated conservatively, the second and third were operated upon. The results in all four cases were satisfactory. The author then gives a most valuable abstract of all available reported cases of torn crucial ligaments and fracture of the tibial spine, with particular reference to the methods of treatment employed and the outcome of these treatments. The following conclusions are reached:—Ruptures of the crucial ligaments are not as serious as they were at one time thought to be. Serviceable joints may be expected and the operative risks are small. Tunneling operations and transference of muscles or transplants of fascia are rarely called for. The median patellar incision gives the best exposure of the joint. A "cage" splint as a protection must be worn for several months after walking is begun. Avulsions of the tibial spine are best treated conservatively, a plaster cast with the leg in complete extension. If the contours of the articular surfaces of the femur and tibia have not been disturbed by the injury a good functional result may be expected.—*Walter G. Elmer, M.D., Philadelphia.*

CONCERNING A CASE OF PARTIAL FRACTURE OF THE TIBIAL SPINE. H. L. Rocher. *Revue d'Orthopédie*, September, 1922, p. 469.

Three types of this lesion are recognized: (1), avulsion of the tibial spine; (2), fracture of the external tubercle; (3), wound of the tibial spine combined with fracture of the tuberosity.

In 1000 cases of fracture Kurlander found only three cases of fracture of the spine of the tibia. He regards it as a rare fracture caused by indirect violence through sudden, sharp pull on the crucial ligaments. His treatment consists in complete extension of the knee under anæsthetic and immobilization for eight to ten weeks, followed by massage. If blocking occurs, the knee is opened through longitudinal patellar incision and the obstruction removed.

Tanton describes total and partial fractures of the tibial spine.

Such a case is reported under the above title by Rocher as follows:

A soldier fell from his horse in December, 1916, landing on one foot. Voluminous hemarthrosis of the knee occurred and was punctured. First seen by the author in July, 1917. No swelling. Pain and limping. Flexion limited to 140 degrees, extension to 155. Sharp pain on attempt to pass these limits. No lateral laxity when in extension, but some on flexion. Roentgenogram showed partial fracture of tibial spine including a quadrilateral fragment of the internal tubercle which was slightly tilted upward and backward. In order to walk, the patient stiffened his entire lower leg, otherwise the knee would rotate inward due to laxity of the crucial ligaments. He was advised not to have any operative interference, since consolidation seemed to be complete. With a brace holding the knee in as much extension as possible he was able to go back into service.—*William Arthur Clark, M.D., Pasadena, Calif.*

FRACTURE OF THE SPINE OF THE TIBIA. R. Stephens. *Journal A. M. A.*, March 31, 1923, p. 905.

The condition "is one of rather extreme rarity." The author has seen two cases in the last six years.

Case 1. A soldier, 19 years old, was tackled at football and brought to the ground. The knee showed extensive ecchymosis, heat, increased fluid, and almost complete limitation of motion. There was no marked lateral mobility. X-ray showed fracture of the upper end of the tibia in the knee joint, with a fragment including the entire spine of the tibia. The further history of this case is not available.

Case 2. Aged 16, was tackled at football and thrown to the ground For 4 months he was treated for sprained knee. There was no lateral mobility. He walked with a slight limp. X-ray showed fracture of the external tubercle of the spine with two small fragments detached.

The joint was opened by splitting the patella, and small bone fragments were found embedded in fibrous tissue. The mass of fibrous tissue which jammed between femur and tibia on attempted extension was excised.

Active movement was begun immediately, and walking was resumed on the 10th day. When seen later, function was normal and no discomfort of any kind was experienced. A short summary of the literature is given. The cause is always some severe traumatism that holds the leg and causes the body to twist violently, with the strain at the knee joint. The injury is frequently associated with rupture of crucial ligaments. Direct impingement of external margin of internal condyle on spine, or avulsion of the bony attachment of a crucial ligament probably causes the injury, as in analogous fractures about the ankle.

Treatment in early cases should be conservative. In late cases open operation for removal of the fragments is usually necessary. The final results are excellent in all cases.—*Alexander Gibson, F.R.C.S., Winnipeg.*

THE TREATMENT OF OLD, UNUNITED FRACTURES OF LONG BONES, WITH SPECIAL REFERENCE TO THE USE OF THE OSTEOPERIOSTEAL GRAFT. Henry Bascom Thomas, M.D. *Journal American Medical Association*, February 3, 1923.

Dr. Thomas in his paper brings out the necessity, as borne out by experience in the World War, of waiting for a year or more in compound ununited fractures before attempting repair by means of bone grafts. He lays special stress upon not disturbing the old ends of fragments because of uncovering sources of latent infection. He also recommends the use of a periosteal wafer graft composed of a layer of periosteum and a thin layer of bone in one piece as a means of supplying osteogenetic cells with a good blood supply, which is highly important in securing firm union.

The ordinary graft insert is cut a little wide, which insures a better fit. Over this is placed the wafer periosteal graft, which is sewed in place and holds the deep one, thus doing away with the necessity of pegs, screws, or sutures in the deeper insert.

The paper is illustrated by nine excellent cuts. Dr. Thomas also points out that the operation does not cease with cutting surgery and that the surgeon should also give his personal attention to the application of an appropriate splint, which he claims is no doubt the most important part of the entire procedure.—*H. A. Pingree, M.D., Portland, Maine.*

TREATMENT OF DUPUYTREN'S FRACTURE BY A SCREW THROUGH THE INTERNAL MALLEOLUS. G. Leclerc. *La Presse Médicale*, February 21, 1923, p. 165.

The author is convinced that the open and precise method in treatment of fractures is gaining ground, and that in a few years it will be the method of choice in all cases. There are too many poor and indifferent results by the closed method.

Fractures about the ankle especially need open operation. Disregarding the former classification by mechanism, most surgeons today think of these fractures as: (1) Fracture of one malleolus. (2) Fracture involving both malleoli. (3) Fracture of internal malleolus with fracture of lower end of fibula (Dupuytren type). (4) Internal malleolus and upper part of fibula (Maisonneuve type).

The usual treatment of the Dupuytren type has been to put up the foot in plaster in forced adduction. But the tibiotarsal mortice is not restored precisely by this method, and exact restitution is demanded in a joint of such importance. The Delbet walking plaster splint has been advocated for this fracture but it is illogical, because the fracture lies below the inferior point of support. The Championnière mobilization method is also illogical in this region because it ignores anatomical reduction.

The external malleolus is of lesser importance because the fibula takes no part in weight bearing, but the inner malleolus must be restored to its anatomical position and held there. This will bring the astragalus into proper relation

and indirectly through the malleolar ligaments will also put the external malleolus in good, though perhaps not anatomical, position.

The author uses a long screw to hold the internal malleolus in place. He has practised this method since before the war and has been able to note excellent late results. Juvara accomplishes the same result by nailing.

The operation can be done with local anaesthetic. The tibiotarsal joint as well as the fracture line and surrounding skin is well infiltrated with the liquid anesthetic and incision is made curved with convexity downward under the internal malleolus. The flap is turned upward and longitudinal incision then made along the malleolus up to the line of fracture. The periosteum is separated and the soft parts retracted out of the way. Having obtained reduction by lion-tooth forceps or otherwise, a 6 cm. screw is inserted through the malleolus and sunk into the tibia pointing upward and somewhat inward. The leg is placed in a wire splint and motion is begun in three or four days. The patient begins to walk in about a month.—*William Arthur Clark, M.D., Pasadena, Calif.*

OSTEOMYELITIS

OSTEOMYELITIS OF THE ILIUM IN CHILDREN. Carl Bearse. *Journal A. M. A.*, April 7, 1923, p. 991.

Infection of the ilium, far from rare, is most serious in children because of the difficulty of diagnosis. This condition should always be borne in mind in cases of painful hip that permit motion. Of the bones of the pelvic girdle the ilium is most frequently infected.

Two case reports are given:

1. Boy aged nine. Previous attacks of osteomyelitis, swelling of right hip, with fever and prostration. At operation a hole was found in the ilium near the crest.

2. Boy aged 13. Injury while playing football. High temperature, haematuria, sensitive right hip. At operation 4 ounces of pus were found and a bare area on the ilium with a perforation in the centre. Culture showed staphylococcus aureus.

Complications are frequent, such as dislocation of the hip joint, metastasis, amyloid liver, erosion of the femoral artery.

The treatment is early operation with adequate drainage and removal of dead bone, even if it means resecting the whole ilium.—*Alexander Gibson, F.R.C.S., Winnipeg.*

ACUTE OSTEOMYELITIS. Frank LeMoyne Hupp. *N. Y. Med. Jour. and Med Rec.*, October 18, 1922.

Osteomyelitis is in a class by itself, a disease wholly surgical, and the medi-

cal men must know the symptoms, recognize them without delay, and join hands with the surgeon for immediate and correct operative relief. There is scarcely any other well known and frequently seen disease in our hospitals today with respect to which there have been so many sins of omission and commission. Within a few hours of the onset of the acute symptoms of a virulent osteomyelitis, "the induction of pyogenesis in the medullary canal is followed by an enormous osteoblastic proliferation in the bone tissues, which is rapidly extended onto the surface, filling the areolar meshes, where the osteoblasts form osseous plaques and become adherent to the periosteum." The infection spreads with great rapidity beneath the periosteum, dissecting loose this fibrous membrane, and only limited at either extremity by the epiphyseal plates. There are many points in common in the early symptoms of rheumatism and osteomyelitis. The pain is severe and acute in both, the tenderness marked, and the white cell count increased with hyperpyrexia. In rheumatism frequently more than one joint is involved, unless the infection is Neisserian. In osteomyelitis rarely more than one locality is invaded, and a white cell count may run from twenty-five to forty thousand. There is greater intensity of the local symptoms, with involvement of the shaft or epiphysis, rather than the joints, and the constitutional disturbances are more profound. Very early there appears a slight edema and redness over the affected shaft, temperature often 104° to 105°, delirium, and profound exhaustion. The wise clinician will not wait for abscess formation and fluctuation, with this perfectly clear picture, but will give his patient that same prompt and wise counsel which he would an acute appendicitis. As the pathology advances, the pus of an osteomyelitis may perforate into a joint and confuse the picture with a septic arthritis, but the true lesion should be recognized before this disaster has occurred. How often has one seen a delay in the recognition of the pathologic condition until the pus has reached the surface of the bone, and the timid operator has satisfied his conscience with an incision of the abscess. He thinks he has done his duty, while the smouldering destructive volcano within the medullary cavity invites his trephine, chisel, and mallet. The medullary spaces everywhere communicate, so that a liberal opening through the cortex of the bone into the infected cylinder provides ample drainage in the acute stage of the disease. The bone curette must not be used in the medullary canal, for to trammatize the endosteum would be as irrational as to scrape the membranes and vascular lining of a phlegmon elsewhere in the body, and may lead to a destruction and necrosis in the bony canal.—*Walter G. Elmer, Philadelphia.*

ACUTE OSTEOMYELITIS IN CHILDREN: REPORT OF CASES. J. C. Willis, Sr., and J. C. Willis, Jr. *New Orleans Med. and Surg. Journ.*, January, 1923.

Four cases are reported and the disease is described very carefully as to its etiology, course, and differential diagnosis. The authors make a plea that the disease be treated wholly surgically; the earlier the operation the better the outlook for life and limb. The medullary cavity should be given prompt and efficient drainage.—*Edward S. Hatch, M.D., New Orleans, La.*

POSTURAL AND STATIC DISTURBANCES.

MODIFIED OPERATION FOR HALLUX VALGUS. S. Keszly. *Zentralblatt f. Chir.*, Jan. 20, 1923.

The operation consists of five phases:

1. Four to five cm. long incision on the median surface of the metatarsophalangeal joint of the big toe. Removal of bursal sac.

2. Chiseling off of the exostosis and smoothing of the bone wound.

3. Wedge shaped resection of the head of the metatarsal. The wedge has its base on the inner border, its apex on the outer border of the foot, and reaches the neck of the metatarsal. The direction of the wedge and its size are of importance and depend upon the degree of toe deviation. The purpose is to bring the articulating surface in line with the long axis of the metatarsal shaft and the toe in the direction of Meyer's line. It is essential that the wedge be removed as near the metatarsal head as possible and that the head should not be chiseled through entirely, but only to the cortical layer of the external surface, thus leaving it and its periosteal covering untouched. The remaining joint end is pressed against the stump of the metatarsal shaft and the toe thus brought in the desired direction. Closure of joint capsule.

4. Tendon transplantation. The tendon of the musc. extens. hallucis longus is split in two and an inner arm is attached to the base of the last phalanx. This tendon plastic is for the purpose of retaining the toe in the corrected position.

5. Closure of the incision.—*A. Gottlieb, M.D., Los Angeles.*

ORTHOSTATIC ALBUMINURIA. Wilbur E. Post, M.D., and William A. Thomas, M.D. *Journal American Medical Association*, February 3, 1923.

The authors have given a rather exhaustive consideration of the subject and have quoted extensively from the investigation of others. It does not appear that lordosis, the horizontal position, or the upright position of the body are important factors in the production or control of albuminuria. Their summary and conclusions follow:

SUMMARY.

Observations covering approximately forty cases of orthostatic albuminuria indicate that the appearance of variable amounts of nucleo-albumin and serum-albumin in the urine in such cases is analogous to changes taking place in the blood and body tissues.

The condition, which appears most frequently in the young, in certain types of individuals, particularly the undernourished, rapidly-growing ones, with unstable venous and vasomotor mechanisms, and frequent or chronic infections, is accompanied by a pulse pressure smaller in the upright than in the lying position, is aggravated by immobility, and presages no progressive renal disease.

Repeated and accurate functional tests and blood chemistry observations reveal neither constant deviations from the normal nor constant variations between the upright and horizontal positions.

CONCLUSIONS.

1. Neutralization or mild alkalization of the urine produces changes in the kidney, blood, or body tissues which are followed by disappearance of nucleoalbumin and serum albumin from the urine, by restoring to normal the physicochemical state of the proteins and preventing their escape into the urine.

2. Neutralization may be brought about by administration of various alkaline salts, such as sodium or potassium acetate, or sodium citrate or calcium lactate, and similarly by the vegetables and fruits in the diet that contain alkalizing salts.

3. Other factors influencing this form of albumin in the urine are: circulatory efficiency in the kidney itself or in the body itself, and metabolic efficiency in the blood and body tissues as influenced by other factors than circulation, such as the conditions producing rapid growth in youth, and by infections and intoxications.—*H. A. Pingree, M.D., Portland, Maine.*

IS ORTHOSTATIC ALBUMINURIA A UNILATERAL DISORDER? Clarence Quinan. *Journal A. M. A.*, March 31, 1923, p. 899.

Pavy first described in 1885 a condition in which albuminuria is present while the patient is up and about, but disappears after rest in bed. In this paper are detailed the results of some kidney fixation experiments in a marked case of orthostatic albuminuria. These experiments cover a period of eight years.

Germane to the subject are:

1. *Palpatory albuminuria.* The fact seems to be established that manipulation of the renal cortex causes albumin to appear in the urine.

2. *Movable kidney and lordosis.* On the theory that orthostatic albuminuria connotes a venous stasis due to compression of the renal veins, it is held that renal mobility and lordosis facilitate obstruction. Even in the horizontal decubitus it is believed albuminuria can be induced by lying on a hard pillow.

3. *Clinostatic albuminuria.* "In some patients with considerable splenic enlargement, rest in bed or in the recumbent position may be accompanied by albuminuria, and the albumin may disappear from the urine when the patient assumes the erect position."

4. *Ureteral catheterization.* In a case recorded by Vorpahl the albumin came from the right kidney alone. Sonne, on the other hand, advanced the idea that orthostatic albuminuria was always left sided, and was due to compression of the left renal vein by the lordotic vertebral column, the pressure probably being transmitted through the abdominal aorta.

Case report. A man aged 30, erect, muscular, free from lordosis, has had for at least eight years a clino-orthostatic albuminuria. The right kidney was freely movable. A kidney clamp was devised to provide fixation of one kidney at a time. Forty experiments were made and 120 samples of urine were tested by Esbach's method. Experimentally, the orthostatic albuminuria was not

affected by the supporting of either kidney alone, or both kidneys together. On the other hand, the clinostatic albuminuria could be greatly reduced by having him sleep with the foot of the bed raised a few inches.

The writer's conclusion is that no support is lent to Sonne's theory that orthostatic albuminuria is always left-sided.

Ureteral catheterization was never carried out. The suggestion is made that a purely mechanical origin for the malady is inadmissable. Probably several factors are concerned, and one of these in all probability will have to be sought for in the autonomic nervous system.—*Alexander Gibson, F.R.C.S., Winnipeg.*

A Note on the Question of the Causation of Postural or Orthostatic Albuminuria. F. Parker Weber. *British Jour. Children's Diseases.* April-June, 1922.

True orthostatic albuminuria is often connected with the tall, "lanky" build of body suggestive of visceroptosis, in which there is often some degree of lordosis likewise present. In cases of orthostatic albuminuria, temporary albuminuria can sometimes be produced by artificial lordosis, even when the patient remains lying in bed. The suggested explanation is that the albumin comes from the left kidney, only due to lordotic pressure on the left renal vein, which has to pass in front of the vertebral column and the aorta. This is confirmed by catheretizing the ureters. Both granular and hyaline tube casts can often be detected in the albuminous urine from cases of orthostatic albuminuria. Lordosis cannot be the only factor in the cause. There must also be an individual predisposition. It is often in the morning that the albuminuria is most marked. It occurs chiefly, but not always, in early life, up to 25 or 30 years of age. Lordosis does not always produce orthostatic albuminuria. Enlarged spleen and hepatic cirrhosis may be a factor. Hematuria may be present when marked lordosis mechanically disturbs the circulation of the left kidney. In uncomplicated cases of orthostatic albuminuria the life may be regarded as a normal one from the life assurance point of view.—*Walter G. Elmer, M.D., Philadelphia.*

An Operation for Hallux Valgus. Percy W. Roberts. *Jour. A. M. A.*, Feb. 24, 1923, p. 540.

The author presents a new and interesting operation for hallux valgus deformity. He reaches the operative field through an elliptic incision which permits the removal of the redundant skin and bursa in one mass. The tendon of the extensor hallucis is cut a short distance above its insertion; the tendon and its sheath is dissected free to a point above the head of the first metatarsal. The tendon is then implanted in a shallow canal on the medial side of the base of the first phalanx, covered with periosteum, and sutured into position. A wedge is excised from the base of the first phalanx, and its articular surface is concaved. A wire splint is used between the first and second toes in the dressing. The article is well illustrated.—*Edward S. Hatch, M.D., New Orleans, La.*

FOOT STRAIN IN GOLF. N. D. Mattison. *N. Y. Med. Jour. and Med. Record*, Feb. 7, 1923.

As stated by the author, this article is intended to direct attention to the feet as a factor in control and maintenance of body balance and to the causes and results of foot strain due to habitually faulty use of the feet, particularly in the playing of golf.

This is a lengthy and intricate discussion of the physics and mechanics of weight bearing and movements as they affect the feet of the golfer. It is claimed that the game makes exacting demands on the feet, chiefly because the player does not usually keep his feet parallel during the strokes.

While this attitude of the feet is generally conceded to be the strong position for ordinary standing and walking it does not necessarily follow that it is best for either one's feet or one's game to maintain this parallel position while making a stroke at golf. The author fails to note that in the usual "stance" (with toes pointing more or less laterally) the legs and thighs are correspondingly everted with knees slightly flexed and facing in the same direction as the feet. This means that this does not necessarily involve or encourage pronation of the foot in relation to leg, even while addressing the ball, but is the natural position which gives greater stability and freedom during the rotary movement of the body in making the stroke. One cannot make a full, free swing of a golf club with both feet held parallel and firmly implanted throughout the stroke. Rotation to the right would be checked or undue strain be thrown upon the right knee and ankle before the "top of the swing" could be reached. It will be noted that during the back stroke and first half of the forward stroke (until the club strikes the ball) most of the body weight is on the right foot, and that during this period the body and right thigh and leg are rotated to the right in relation to the foot, i. e., the foot is more or less inverted and adducted on the leg during this period, even in the usual stance. The left foot is likewise protected during the finish of the stroke when it has to bear most of the body weight.

The author seems to have overlooked some important factors in his study of golf strokes.—*R. W. Billington, M.D., Nashville.*

MISCELLANEOUS

CONTRACTED ACHILLES TENDON. A. Gottlieb. *N. Y. Med. Jour. and Med. Record*, Feb. 7, 1923.

The conditions generally included by this are, in fact, usually contractures of the calf muscles rather than of the Achilles tendon. It may be congenital or acquired, 96 per cent being of the latter. Causes of acquired types include: trauma to leg, ankle, and foot, prolonged faulty position in bedridden patients, constitutional diseases, such as gout and chronic arthritis, spastic and flaccid paralysis, especially poliomyelitis, local acute and chronic inflammation of ankle joint and calf muscles, and habitual wearing of high heeled shoes.

Some of the usual preventive and corrective methods of treatment are briefly discussed.—*R. W. Billington, M.D., Nashville.*

Osteitis of the Iliac Bone. Aug. Broca. *Paris Médicale*, February 24, 1923.

Some interesting roentgenograms of extensive osteomyelitis of the pelvic bones are shown, and five cases are reported.

Case 1. Girl of 12. Cold abscess draining on the posterior lateral aspect of the thigh for the past six weeks. Has had trouble, however, for the past five years. This seemed to be a tubercular abscess, in spite of the positive Wasserman. A sequestrum was extracted in May, 1912. The sacro-iliac joint was involved and became ankylosed, and the affected half of the pelvis became distorted and pushed upward. The picture shows the upper half of the ilium denuded, rough, and irregular. The girl was sent to Berck in July, 1913, the sinus having closed without another operation. Mixed treatment had no effect on the bone condition.

Case 2. Child of 6. Large abscess over left ilium from which five sequestra were removed. A persistent fistula required another operation, and after about five years the patient recovered. Roentgenogram showed upper posterior two-thirds of ilium honeycombed and edges serrated.

Osteitis in this region of the pelvis does not involve the hip, but in the pubic and ischial bones the disease may involve the joint also.

Case 3. A boy of nine; died from an extensive necrosis of the pubis and ischium which invaded the hip after three years duration.

Case 4. A boy of eight, had the same condition in the pubic bone where it was possible to remove the sequestrum without disturbing the joint. He recovered.

Case 5. A boy of five who had an abscess in the pubic bone. A sequestrum was removed about eighteen months after onset of the disease. Not seen since then.—*William Arthur Clark, M.D., Pasadena, Calif.*

Osteo-Articular Syphilis. Paul Gastou. *Paris Médicale*, March 3, 1923, p. 200.

Diagnosis of syphilitic lesion of the bones and joints has always been rather difficult because of confusion with tuberculosis, chronic rheumatism, infectious arthritis, gonorrheal arthritis, and arthropathies of nervous origin. In addition, the luetic affection may be masked by trauma or acute infection.

Fouquet and Benazet classify the acquired lesions as follows:

Secondary arthropathies, including subacute synovitis, chronic synovitis and hydrarthrosis; tertiary, including osteo-chondro-arthropathy, syphilitic white swelling, gummatous peri-synovitis.

Fournier estimated that 39% of the cases were hereditary and von Huppel states that the percentage is 56.

The following varieties are described by Fournier: 1. Arthralgic form with rheumatoid pains. 2. Hydrarthrosis. 3. Osteo-arthritic form of slow development with pain and formation of hard masses simulating foreign bodies. 4. White tumor, a globular shaped swelling of a joint without loss of function. 5. Arthropathy with involvement of ephiphysis, osteophytic vegetations, muscu-

lar atrophy, and limited motion. 6. Rheumatic deformity type localized in the large joints. To these may be added the arthropathies from tabes and other nervous affection of luetic origin.

Five cases are reported by the author.

Case 1. Man of 20. Pain, swelling, and loss of function in both knees and in fingers of one hand coming on three months after primary chancre. Roentgenogram negative. Temperature 37.8 to 38.4. Positive Wasserman. Joint condition cleared up under mercury.

Case 2. A man of 60 had had a primary lesion at 18. Troubled for several years lately with swelling and pain in the left knee. Tenderness and more or less disturbance of function. Wasserman positive. Finally in 1921 came a crisis with complete loss of function in the joint. In 1922 another crisis with intense pain over the patella, keeping him in bed. Skin red and tender, giving an appearance of suppuration. Roentgenogram showed erasion of the patella, points of rarefaction in upper end of tibia, roughening of the articular surface, and irregular proliferation of the periosteum. This man was cured by antisyphilitic treatment so that he was able to return to work.

Case 3. A woman with pain, swelling, and disability of left knee. Her husband died of a mediastinal growth which was not correctly diagnosed but which on later consideration and in view of a positive Wasserman in the woman was regarded as luetic. The knee swelling was globular in contour and tender on the sides. Flexion almost impossible and very painful. Roentgenogram showed proliferative lesions of the tibia and femur near the joint, irregular articular surface and nothing around the joint. A diagnosis of joint syphilis was deemed justifiable because of the positive serologic tests and the family history. Treatment was not effective, but, however, not very intensive.

Case 4. Woman of 60 with painful swelling of both knees which showed osteophytic proliferation and periarticular mottling. She and her husband had positive Wasserman tests.

Case 5. Woman whose father had died with tabes, began to have pain in the knees at 30. At 40 she had also pain and swellings in fingers of both hands. She had inequality of pupils. Argyll-Robertson reaction, frequent incontinence of urine and absent knee-jerks. Bordet-Wasserman reaction negative but Hecht positive. This case is considered a late manifestation of hereditary syphilis.

The acquired form of luetic osteoarthritis is characterized (1) by swelling, usually without redness or fluctuation, except in case of hydrarthrosis; (2) by pain, either spontaneous or on movement, and tenderness on pressure; (3) by impairment or loss of function. The lesion is frequently bilateral and sometimes multiple.

Roentgenographic findings are of three types: (1) proliferative, with periosteal thickening and osteophytes on the epiphyses or on the cartilages; (2) rarefying type, showing clear spaces which later become sclerotic: (3) destructive type, similar to tuberculosis. In severe cases the inter-articular line may be narrow and irregular and the destruction may be so great that loose bodies can be seen.

Clinically, a differential diagnosis must be made from chronic infectious arthritis, sarcoma, tuberculosis, and osteomyelitis.

Arsenic preparations intravenously associated with bismuth, mercury, and iodides should be used in treatment. A bismuth preparation known as muthanol seems to be especially efficacious in these joint lesions.—*William Arthur Clark, M.D., Pasadena, Calif.*

THE ROLE OF SUNLIGHT IN PROPHYLAXIS AND TREATMENT OF RACHITIS. P. F. Armand-Delille. *La Presse Medicale*, February 17, 1923, p. 159.

Since the celebrated work of Glisson in 1659, rachitis has been the subject of innumerable studies. Among the numerous theories, the intestinal factor seems to hold first place now, and since the discovery of vitamins, it has been thought that a key to the problem is now available. Lately the work of Rollier, Hess, and others shows that sunlight plays an important part in nourishment and that its absence favors development of rachitis. Hess and his co-workers conclude after comprehensive studies that vitamins have only a secondary effect and that their absence does not predispose to rachitis. The idea that phosphorus and calcium are lacking in the diet of rachitic children is dismissed by the findings of Sherman and Pappenheimer that human or cow's milk contains more than enough of those elements to supply the bones.

In his studies, Hess was struck by the increase in number of rachitis cases in winter and spring and decrease in summer. Acting on this suggestion, he began to expose the rachitic patients to the direct sunlight. The results were very encouraging. Not only did the children gain in vigor and general nutrition, but the symptoms of rachitis rapidly disappeared. The epiphyseal tumefactions subsided in the parts not directly exposed to the sun rays, proving that heliotherapy has a general and not merely a local reaction. In a series of cases it was found that during sun treatment the phosphorus content of the blood was raised from 2.8% to 4.13% in one case, in three months treatment, 2.77% to 4% in another, and 3% to 4% in another case after four months. Experiments with white rats in which rachitis was produced by diet showed that the development of the rachitic symptoms was precluded by keeping the animals in direct sunlight.

Vallot, at Nice, was able to increase metabolism by heliotherapy. In some cases the assimilation of certain food substances was increased two and a half times. It was once thought that sea air was necessary in conjunction with heliotherapy but this idea has been refuted by the remarkable results obtained by Rollier in the mountains. Also it was observed by the author that a child of 2½ years was almost completely cured of rachitis by six weeks heliotherapy in Paris while awaiting admission to the hospital at Berck on the sea.—*William Arthur Clark, M.D., Pasadena, Calif.*

RESECTION OF THE KNEE BY MEANS OF A SAW WITH TWO PARALLEL ADJUSTABLE BLADES. J. Calvé and M. Galland. *La Presse Médicale*, March 7, 1923, p. 379.

Resections of the knee joint are not always followed by good results either

because solid union fails or because the union is obtained in a bad position. A frequent cause of failure to get an ankylosis is poor coaptation of the new surfaces. The surgeon may make a slight error in the angle of resection on one bone or the other; even if this is discovered the attempt to correct it usually leaves a rolling instead of a flat surface. Another difficulty is that although the leg is placed in proper alignment in a cast the resection surfaces may not be in apposition because of slight movement inside the cast. There may be a sinking backward or a slight lateral motion giving rise to valgus or a varus deformity.

To obviate these difficulties, Dr. Galland devised a double bladed saw with which to make both tibial and femoral cuts at the same time. The parallel blades of the saw are adjustable to the desired width of resection, and it is impossible to have one surface at an angle with the other when the saw cuts are made. It is not even necessary to make the cuts perpendicular to the long axis of the bone because the two surfaces being absolutely parallel, both laterally and antero-posteriorly, they will fit together. The knee is held at the angle at which consolidation is desired by placing a sand bag of proper thickness under it.

Nothing is said in this paper about the handling of the soft parts. It would seem that in order to make the perpendicular saw cuts clear through the bone with the knee extended a very extensive incision would be necessary.—*William Arthur Clark, M.D., Pasadena, Calif.*

OSTEOMALACIA WITH EPILEPSY. A. Brenner. *Deutsch. Ztschr. f. Chir.*, Nov., 1922.

The frequency of bone malacia in late years and the uncertainly of its etiology warrant the quoting of a case of osteomalacia with epilepsy which, briefly, is as follows:

Woman of 32. Parents healthy but died of "cancer" in advanced age. Grandmother, on mother's side, suffered from sudden attacks of convulsions with loss of consciousness. As an infant, patient was weak and slow in development; had cramps during dentition. As a child, physical and mental growth was retarded; she had the common diseases of childhood. At age of 14 began to earn a living and to perform, at times, pretty strenuous physical labor without any untoward effects. Menstruation began at 14 and was regular and painless.

At age of 25, without previous warning, had epileptic attack with loss of consciousness. Repetition of attacks about every 4 to 6 weeks occurring in the day time and in later years predominantly at night during sleep. Received bromide medication which she did not tolerate and which did not influence the attacks.

When 27 years of age gave birth to child, healthy and strong girl, whom she nursed. Pregnancy and parturition were normal.

Two years later, during the second pregnancy, patient complained of fatigue, difficulty in walking, and a painful, gradually increasing weakness in the legs. She gave birth to a puny boy, who, although breast fed, grew slowly in body

and functions, and developed, at the age of 3, progressive deformities of the legs. During both pregnancies the epileptic attacks were rare; after the second parturition they occurred more frequently and in severer form. During this period, the war time, she and the children suffered great want, lack of food and fuel. About this time, at the age of 29, pain in the region of the pelvis and in the legs made its appearance. The pain was so severe and accompanied with so intense tenderness on the slightest pressure over the lower back, the pelvis, and the legs, that standing or walking became impossible.

Following a particularly long and severe attack, patient was entirely unable to move the left leg, which was extremely painful and rotated outward. She sustained a spontaneous fracture of the neck of the femur. The femoral head was removed and the wound healed in a short time.

At this time the patient noticed that she grew shorter; the spinal column began to bend, the trunk of the body sank, as it were, between the thighs. She became emaciated, pale, lost weight and strength, suffered insomnia, and the epileptic attacks became more frequent. No difficulty in micturition and defecation.

At this time the patient presented herself for treatment of her deformity. The clinical findings were: Highly emaciated woman with a peculiarly sunken and shrunken body; extreme paleness of skin and mucous membrane; no edema, exanthema or glandular enlargements; general musculature markedly feeble and hypotonic; tenderness over the skull, particularly over the frontal tuberosities; no asymmetry of skull; pupils equal, reacting to light and accommodation. No definite abnormalities in oral and nasal cavity; slight enlargement of thyroid. Marked right-sided kyphoscoliosis of the dorsal and lumbar spine. Definite rachitic rosary. Flattened chest which has sunken down and rests on the pelvis. Excessive tenderness on pressure of the entire pelvic ring. The pelvis with its beaklike prominence of the symphysis makes the peculiar impression of having been squeezed together sideways. Marked tenderness of the spine, the sternum, ribs, arms, and knees, which present a genu valgum position, due especially to curving of the femora. Right sided coxa vara with interference of abduction of the thigh; left leg, operated upon and shortened, is in position of inward rotation, adduction, and flexion. Extreme spasm of the adductor muscles of both thighs. Gait is waddling and stiff-legged, taking only very small steps. The epiphyses of all long bones are enlarged. Lungs, heart, and abdominal organs seem normal. Tendon reflexes are exaggerated. Chvostek signs positive. Trousseau negative. Increase of galvanic irritability of motor nerves of extremities. Mental depression and lack of memory. Urine neg. Blood, hglb. 75%, 4 mill. reds; 6900 poly. 50% large and 5% small lympho. 38% mono. 2% eos.

Radiograph: markedly heart-shaped, atrophic, and several times fractured pelvis. The kyphoscoliotic vertebral column sunken into the pelvis so that the transverse processes of the fifth lumbar touch the ilia. Callus formation in the region of the resected left femoral head. Rarefication of the long bones, especially the femora. No changes in the skull bones.

The clinical examination of the children reveals: Girl, 5 years, pronounced rachitic bone changes. Boy, 3, severe rachitis with signs of spasmophilia.

The question presents itself: Shall this case be regarded as a malacia of bone from underfeeding or be considered as a puerperal osteomalacia?

The clinical picture corresponds undoubtedly to the puerperal form, but the course of the disease and, particularly, the existence of tenderness of the skull are characteristic of hunger-malacia. It may be assumed, therefore, that both factors served as causes in the production of this picture.

Significant in this case also is the relation between rickets and osteo-malacia. In the adult, the developed bones of the mother, osteomalacia made its appearance; in the young, the children, rickets developed. In both diseases a derangement of calcium metabolism is obvious, while the clinical pictures vary only in intensity of bone involvement.

The occurrence of epilepsy with osteomalacia, this being the only case reported in recent literature, can be explained only on the basis of a disturbance of endocrine balance, namely, inefficiency of parathyroid secretion which, according to Curschman and Bauer, may result in spasmophilia and tetany during childhood and in epileptiform attacks in later life. Conditional disturbances of the endocrine apparatus in individuals predisposed to epilepsy may give rise to the epileptiform symptomcomplex (Bauer), the conditions here being pregnancy and starvation.

In this patient the hereditary predisposition, a weak skeletal system, spasmophilia, and rickets existed in childhood; at 28 epilepsy broke out, to which were added, four years later, starvation and pregnancy, which acted to complete the picture; osteomalacia with epilepsy.

The treatment was outlined according to Curschman's observations that epilepsy which follows spasmophilia of childhood does not respond to bromide administration. The treatment of epilepsy was disregarded and the entire attention was given to the malacia. Phosphorus was administered in the form of phosphor-cod-liver-oil, which was tolerated in large doses (total phosphorus per day 0.05 G.) and acted like a specific. Besides that, calcium preparations in doses up to 1.0 G. were given daily. Adrenalin injections were tried, but had to be discontinued because of utter intolerance.

The improvement was rapid and effective in every respect; the adductor spasm of the legs disappeared, the intense pain gradually left, all body functions became normal, and the attacks occurred very seldom, were mild and of short duration. Even the x-rays showed changes in bone structure and callus formation of the fractured bones.—*A. Gottlieb, M.D., Los Angeles, Calif.*

TUBERCULOSIS OF ANKLE JOINT AND TARSUS. Henry J. FitzSimmons. *Boston Med. and Surg. Jour.*, Dec. 7, 1922.

The author quotes the figures of Dr. J. W. Sever as given in a paper covering the period from 1868 to 1910, and compares these with the cases treated in the hospital during the last ten years. These latter cases he divides in two groups —those which had been treated conservatively and those which had been operated upon one or more times. The results obtained and the length of time the cases were under treatment are given in detail. In the groups of conservatively treated cases, twenty-five of which are recorded, there developed three cases of tuberculosis of the spine, one case of general tuberculosis, and one case of

tuberculous meningitis. The author reaches the conclusion that the operative treatment of the ankle and tarsus in children is harmful, time is not saved, deformity is not decreased, and motion is not preserved. The cases in the operative group that were followed by the quickest healing and usually by the best surgical results were those that had been submitted to small incisions of the fluctuating mass of an abscess about to spontaneously rupture. Local rest by fixation, protecting against the strain and mechanical pressures to which the individual bones or joints are subjected, should be rigidly enforced. Heliotherapy aids before as well as in the presence of sinuses. A large proportion of cases of tuberculosis of the ankle joint and tarsus get good functional results with very little deformity, but are more likely to get these results in a shorter time by the non-operative procedure.—*Walter G. Elmer, M.D., Philadelphia.*

Osteopsathyrosis: Report of a Case with Roentgenograms of Eleven Different Fractures in the Same Patient. Donald M. Glover. *Archives of Surgery*, November, 1922, p. 464.

This series of roentgenograms gives a graphic fracture history of the patient from the time he was nine months old until his death at 7½ years. Over 200 cases of this condition have been collected by various authors. It is also called fragilitas ossium, and osteogenesis imperfecta.

This case is reported in detail with excellent roentgenograms showing the various fractures. The classification of cases, etiology, pathology, sympatomatology, prognosis, diagnosis, and treatment are discussed. Numerous references to the literature of the subject are given.—*F. G. Hodgson, M.D., Atlanta, Ga.*

Reeducation in Writers' Cramp. P. Kouindjy. *N. Y. Med. Jour. and Med. Rec.*, Nov. 15, 1922.

Occupation cramps are characterized by spastic contraction occurring at the start or in the course of the execution of regular and sustained work. Occupational spasm may occur without being accompanied by the least degree of painful and involuntary contraction of any of the involved muscles. Writers' cramp is the commonest form of occupational cramp and the most extensively studied. Duchenne described three forms: 1, the spastic form, characterized by muscular contraction, either painful or painless; 2, the tremulous form, characterized by clonic or tremulous contraction; and 3, the paralytic form, presenting paresis or even paralysis of one or several muscles. Local conditions such as tenonitis, local neuritis, arthritis, periostitis, myositis, etc., may be a factor in the cause of the disease. They may cause a psychoneurosis which at times attains such a degree that the disturbance exhibits all the earmarks of an affection of central origin. The individual psychic factor of the patient plays an important rôle in writers' cramp. The disease may be called an occupation ataxic neurosis. Many remedies have been tried and have been unsuccessful. The only rational

treatment consists of systematic massage and reeducation, supplemented by hydrotherapy. In the majority of instances of writers' cramp the spasm is located in one or more flexor muscles or in the adductors. These muscles are then in a condition of hypertonicity, while their antagonists, the extensors and abductors, are in a condition of hypotonicity. These latter must be subjected to massage, superficial and deep effleurage, followed by circular and deep pressure, to which are promptly added percussion with the finger or hammer, tappings and vibration treatment. This is supplemented by active exercises for these same muscles. These are described in detail. The patient is then taught to write with the hand inverted, very slowly and deliberately making the strokes, with rest periods in between. These exercises in reeducation are also carried out by the patients at home in the form of set tasks not exceeding twenty to thirty minutes a day. When he has thus learned to write with his extensor muscles, the hand being inverted, he is allowed to write in the ordinary way from time to time on condition that he does so deliberately and slowly. The patient thus acquires the ability to employ regularly two forms of writing. The duration of the treatment is from two to four months, and observation of the patient once or twice a month for several months longer. A treatment at such resorts as Aix-les-Bains or Royat, with local and general douches, may be serviceable in supplementing the treatment.—*Walter G. Elmer, M.D., Philadelphia.*

THE SURGICAL RECONSTRUCTION OF PARALYTIC UPPER EXTREMITY. Arthur Steindler. *Illinois Medical Journal*, March, 1923.

In the treatment of paralytic conditions of the upper extremity Steindler states that we have the following single problems to deal with: the flail shoulder, the flail elbow, the drop wrist, and the flat hand, and outlines his procedures for the care of each condition. For the flail shoulder he advises arthrodesis with the arm in 90 degrees of abduction and slight forward flexion in children, preferably 12 years old or older, and in 70 degrees of abduction in adults.

Inability of elbow flexion is treated by transposition of the flexor group of forearm muscles from their normal attachment to a position two inches higher up on the humerus to increase the slight normal flexor action of these muscles. A pre-requisite to success is some flexor function in the transplanted muscles. For the wrist drop, arthrodesis of the wrist joint has been given the preference in most cases.

The lack of function of the opponens pollicis is overcome by carrying one half of the tendon of the long flexor of the thumb around the metacarpal and fastening it dorsally to the base of the basal phalanx of the thumb. He reports on 40 cases of arthrodesis of the shoulder, 30 flexor plasties of the elbow, 40 arthrodeses of the wrist, and 15 flexor plasties of the thumb. The percentage of successes was large.

(A visit to the Steindler clinic abundantly confirms the striking results he has obtained in his reconstruction surgery of the upper extremity.)—*C. A. Parker, M.D., Chicago.*